Swedish Deep Medicine

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AI4RESEARCH

Research projects

About AI4Research

Contact

AI4RESEARCH

AI4Research is a five-year project tasked with strengthening, renewing and developing research in AI and machine learning.

Grants awarded for 2022

OPEN SEMINARS

2 November: Highly accurate protein structure prediction with AlphaFold

Previous AI4Research seminars

OUR RESEARCH

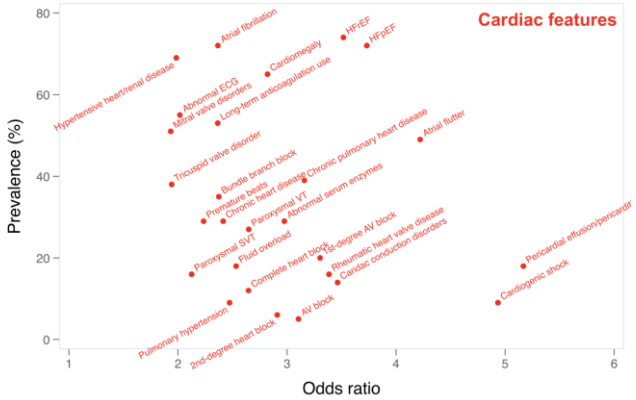
Nine research projects associated with artificial intelligence and machine learning have been awarded funding within AI4Research.

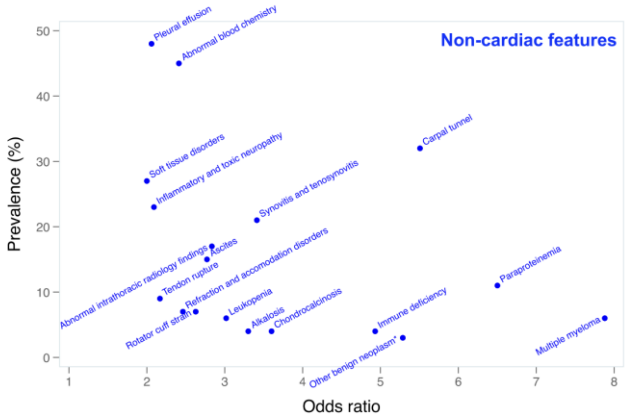
Research projects →

uu.se/awi
uu.se/ai4research

Cautionary tale about a failure to replicate an (overfitted) ML algorithm

Features used





Performance in the US

	Cohort 1: IQVIA holdout (ATTR-CM)	Cohort 2: Optum (ATTR-CM)	Cohort 3: IQVIA (cardiac amyloid)	Cohort 4: Optum (cardiac amyloid)
Sensitivity, %	87	90	56	61
Specificity, %	87	79	83	81
PPV, %	88	81	76	76
NPV, %	86	89	65	67
Accuracy, %	87	84	69	71
ROC AUC	0.93	0.95	0.76	0.78

Performance in Sweden

Metric	Value
PPV	0.200
NPV	0.970
Sensitivity	0.390
Specificity	0.920
Accuracy	0.890
AUROC	0.750
Brier	0.120

Huda et al, Nat Comm 2021;12:2725

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Swedish healthcare data are unbeatable

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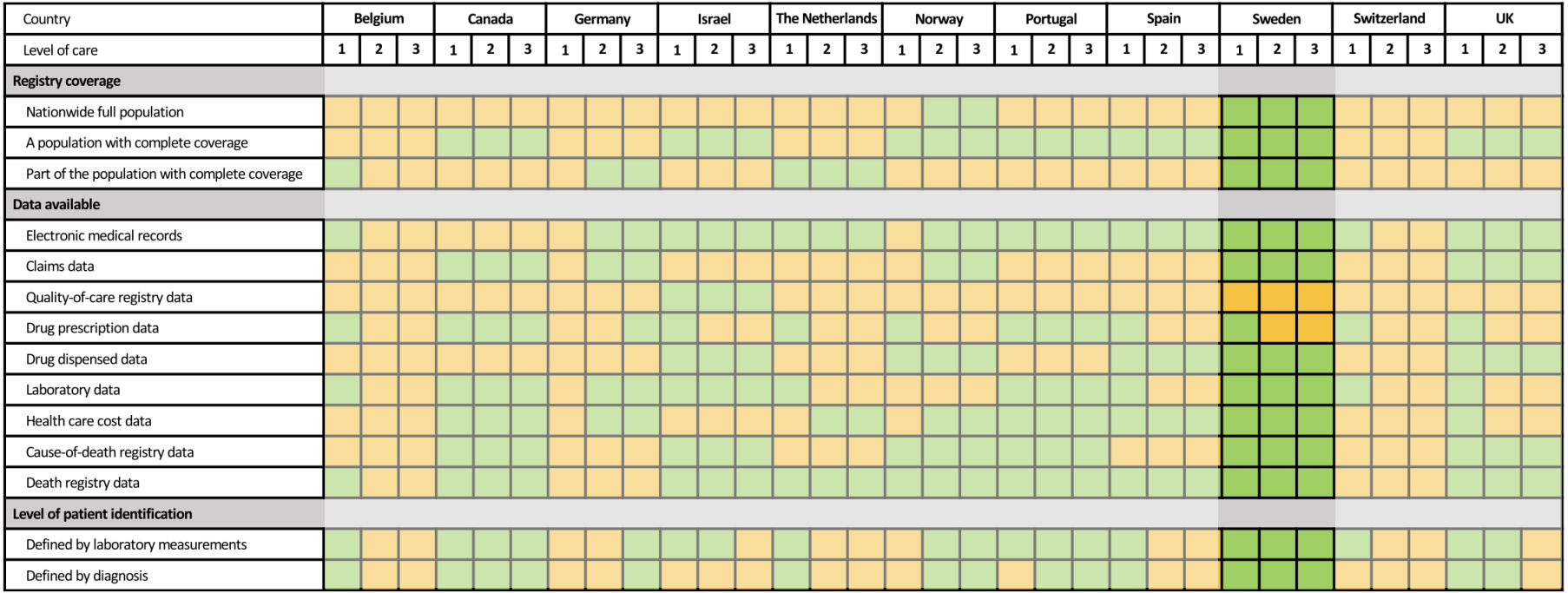
Swedish data sources leading globally

Colors show where data were available and utilized for this study

- Data available and utilized
- Data not available



Sundström et al, Lancet Reg Health Eur 2022;20:100438

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Swedish mandatory registries*

Registry	Contents
Swedish Total Population Registry	Place of residency; country of own and parents' birth; marital status; date of death or emigration
Swedish Censuses	Socio-economic group; education; income; sick leave Sick leave; pensions
Swedish National Insurance Agency Swedish Education Registry	Highest education
Swedish 9th Grade Registry	Junior high school grades
Swedish Multi-Generation Registry	Number of children and siblings; identity of parents if born after 1932 and alive in 1961
Swedish Medical Birth Registry (since 1973)	Numbers of pregnancies and births; pregnancy outcomes
Swedish Prescribed Drug Registry (since 2005)	Pharmacy-expedited drug prescriptions
Swedish Inpatient Registry (since 1964, with complete national coverage since 1987)	Diagnoses of all hospitalizations; surgical and other procedures
Swedish Cancer Registry (since the 1950s)	All cancer diagnoses
Swedish Cause-of-Death Registry	Causes of death, including contributing factors
Swedish Out-Patient Registries (day-care surgery since 1997, all others since 2001)	All diagnoses. Hospital-based mandatory; primary care voluntary

*selection scb.se socialstyrelsen.se

Swedish national quality of care registries

National Quality Register for Bipolar Affe
National Quality Register for Cystic Fibros
National Quality Register for Intensive C
National Quality Register for Psychiatric Care Monitoring (“The Quality Star”)
National Quality Register for ADHD Treat
National Quality Registry for Dementia (S
National Quality Register for Internet Ps
National Quality Register for Psychosis Care (PsykosR)
National Quality Register for Pulmonary Arterial Hypertension (PAH)
National Quality Register for Ankle Arthr
National Quality Registry for Diabetes (N
National Quality Register for Knee Ar
National Quality Register for Rehabilitation for Visual Impairment (SKRS)
National Quality Register for Assisted Re
National Quality Register for Ear, Nose an
National Quality Register for Leukaemia
National Quality Register for Rehabilitation Medicine (Webrehab Sweden)
National Quality Register for Atrial Fibrill
National Quality Register for Eating Disorc
National Quality Register for Liver, Bile I
National Quality Register for Renal Failure (SNR/SRR)
National Quality Register for Behavioura
National Quality Register for Electroconvu
National Quality Register for Lung Canc
National Quality Register for Respiratory Diseases (RiksKOL+ NAR)
National Quality Register for Better Man
National Quality Register for Endovascula
National Quality Register for Macula
National Quality Register for Respiratory Failure
National Quality Register for Bladder Car
National Quality Register for Enhancemer
National Quality Register for Malignant
National Quality Register for Rheumatic Diseases (SRQ)
Heart Disease (Swedeheart)
National Quality Register for Brain Tumo
National Quality Register for Mammogr
National Quality Register for School Health Services
National Quality Register for Breast Canc
National Quality Register for Follow-up of
National Quality Register for Neonatal C
National Quality Register for Shoulder and Elbow Arthroplasty
National Quality Register for Breast Impl
National Quality Register for Forensic Psy
National Quality Register for Neurologic
National Quality Register for Sleep Apnoea
Registry)
National Quality Register for Cardiopulm
National Quality Register for Fractures
National Quality Register for Spinal Dysraphism and Hydrocephalus (MMCUP)
National Quality Register for Caries and
National Quality Register for Gallstone Su
Cholangiopancreatography (GallRiks)
National Quality Register for Neuromus
National Quality Register for Spine Surgery (SWESPINE)
National Quality Register for Cataracts
National Quality Register for Gender Dysp
National Quality Register for Obesity Su
National Quality Register for Stroke (Riksstroke)
National Quality Register for Catheter Ab
National Quality Register for Gynaecologic
National Quality Register for Oesophag
National Quality Register for Systemic Psoriasis Treatment (PsoReg)
National Quality Register for Cervical Car
National Quality Register for Gynaecologic
National Quality Register for Paediatric
National Quality Register for Testicular Cancer (SWENOTECA)
National Quality Register for Child and A
National Quality Register for Haemophilia
National Quality Register for Paediatric
National Quality Register for Thyroid Cancer
National Quality Register for Child and A
National Quality Register for Hand Surger
National Quality Register for Paediatric
National Quality Register for Thyroid, Parathyroid and Adrenal Surgery (SQRTPA)
National Quality Register for Child Preve
National Quality Register for Head and Ne
National Quality Register for Pain Rehab
National Quality Register for Trauma
National Quality Register for Childhood C
National Quality Register for Heart Failure
National Quality Register for Palliative C
National Quality Register for Ulcer Treatment (RiksSår)
National Quality Register for Childhood E
National Quality Register for Hepatitis (Inf
National Quality Register for Pancreatic
National Quality Register for Vascular Surgery (Swedvasc)
National Quality Register for Childhood C
National Quality Register for Hernia
National Quality Register for Penile Cancer
National Quality Register for Cleft Lip an
National Quality Register for Hip Arthropl
National Quality Register for Perioperative Care (SPOR)
National Quality Register for Colorectal C
National Quality Register for Hip Fracture
National Quality Register for Pituitary Disease
National Quality Register for Congenital
National Quality Register for HIV (InfCare
National Quality Register for Podiatric Surgery (RiksFot)
National Quality Register for Congenital
National Quality Register for Infectious Di
National Quality Register for Pregnancy
National Quality Register for Preventative Care (Senior Alert)
National Quality Register for Inflammator
National Quality Register for Primary Immunodeficiency (PIDcare)
National Quality Register for Cruciate Lig
National Quality Register for Inguinal Herr
National Quality Register for Prostate Cancer (NPCR)

kvalitetsregister.se/englishpages

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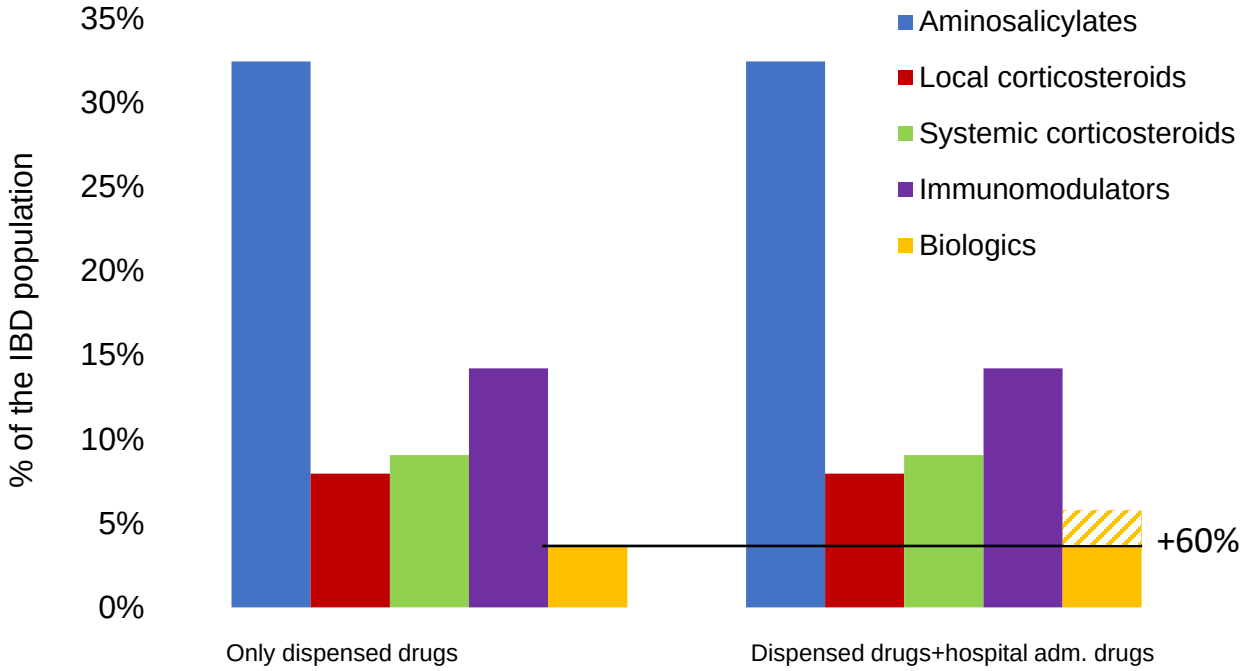
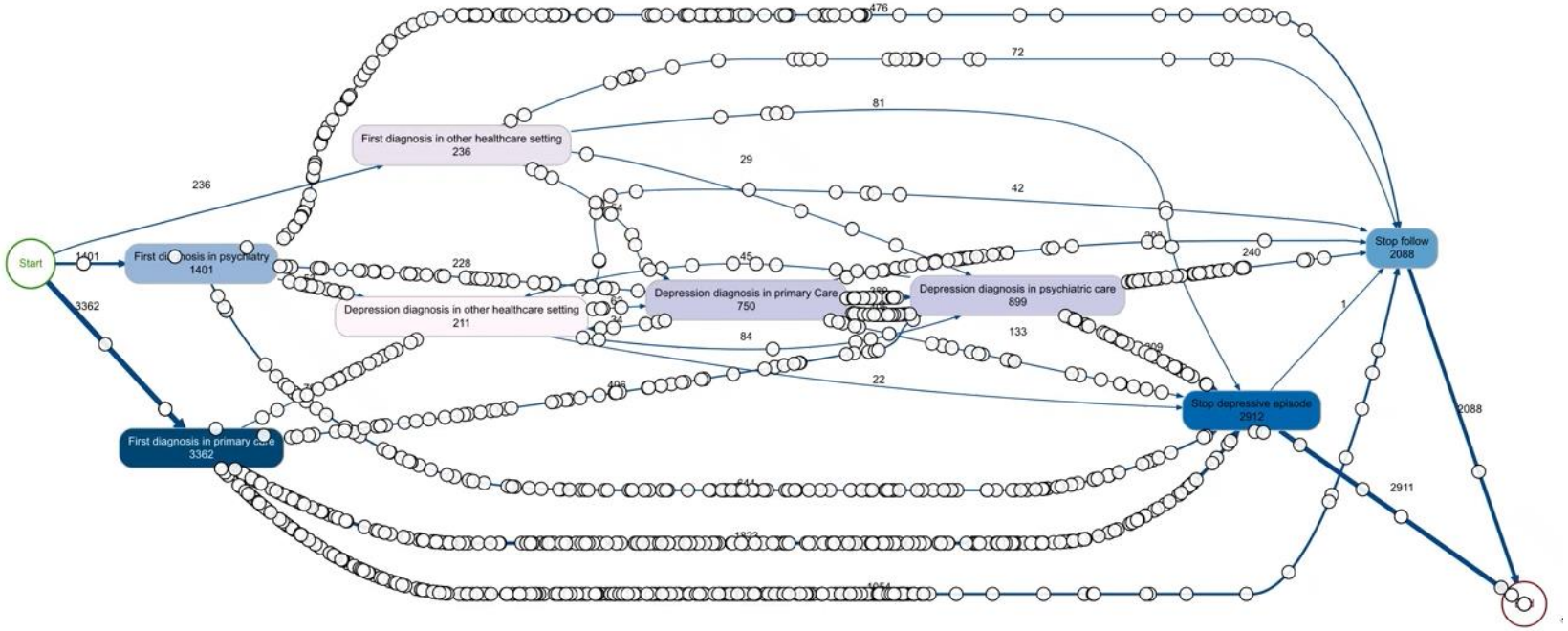
Electronic health records



Cars et al, Basic Clin Pharmacol Toxicol 2013;112:392 & J Crohn's Colitis 2016;10:556

Electronic health records



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Swedish healthcare is equal

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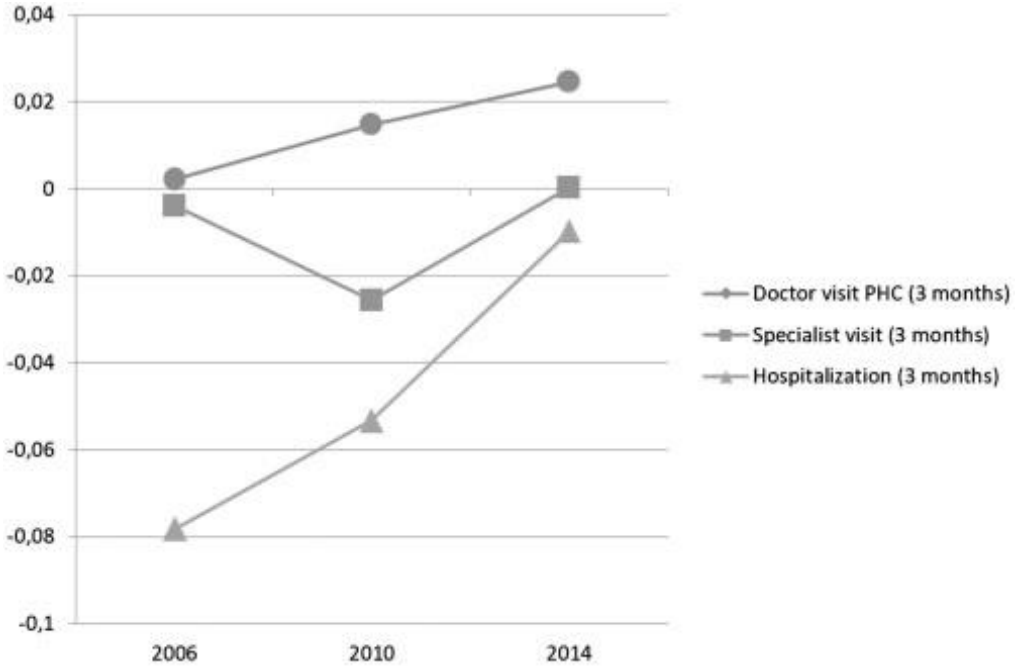
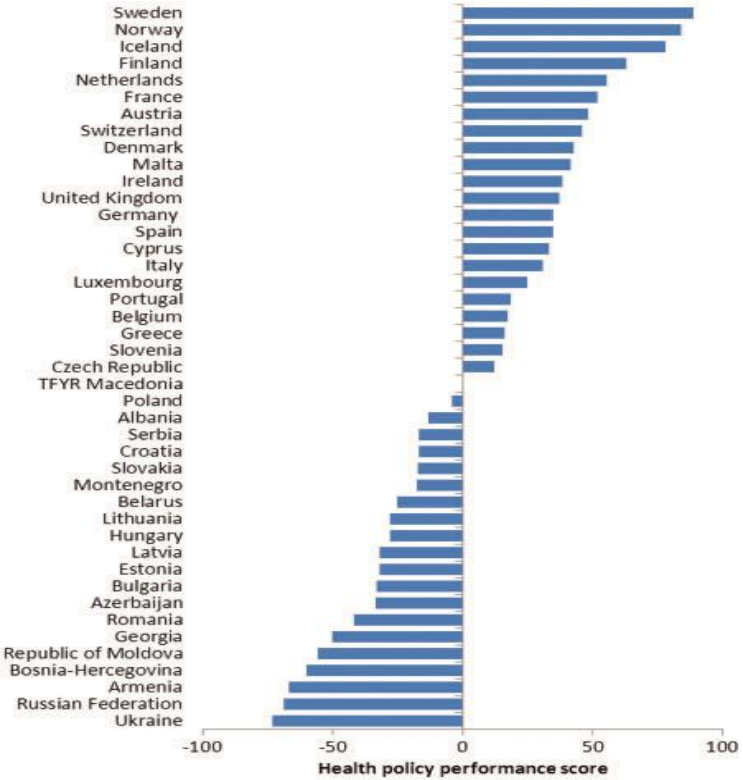
Swedish healthcare is mostly driven by health needs



Trends in the *horizontal inequity index* (difference between observed health care utilization and that which would be expected given the individual's health needs)

San Sebastián et al, Eur J Public Health 2017;27:637

Swedish healthcare is (was?) well governed



Sweden has among the highest *health policy performances* in Europe (a summary score of 27 indicators of success in 10 areas of health policy).

Mackenbach et al, Eur J Public Health 2013;23:195

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EmergAI: Enhancing emergency department safety, efficacy and cost-effectiveness by artificial intelligence

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Emergency department care is unsafe and costly

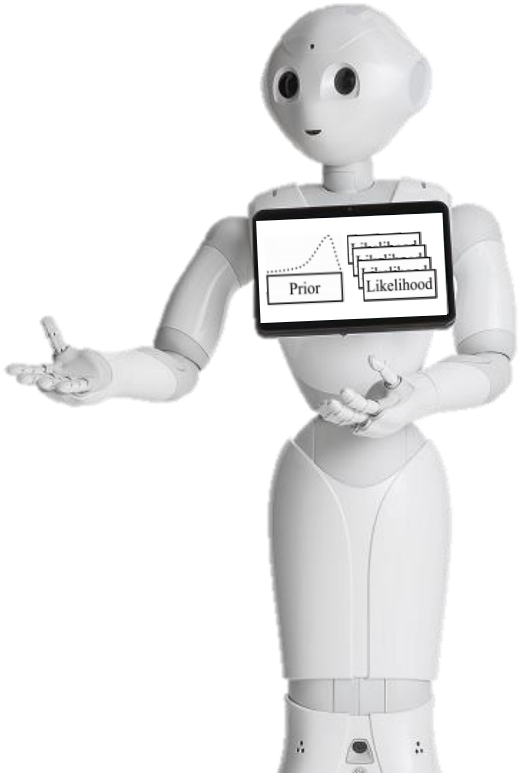
Clinical problems

- Bad statistical intuition of physicians
- Chaotic and stressful environment
- Inefficient documentation and processing of patient data
- Inefficient decision-making

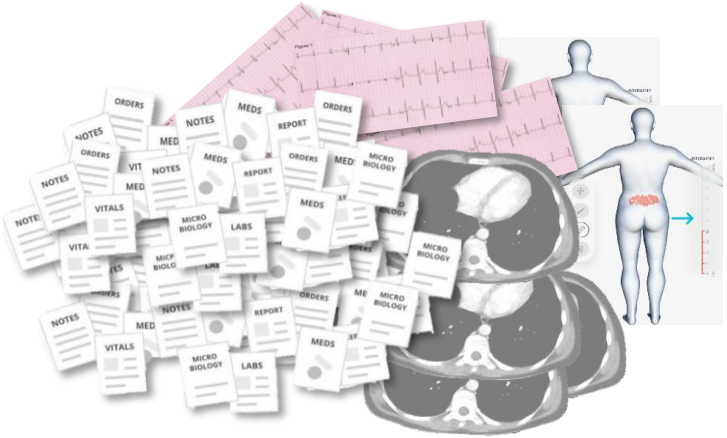
The end goal of this program is a clinical decision support system for the ED, validated in a randomized clinical trial, ready for clinical implementation

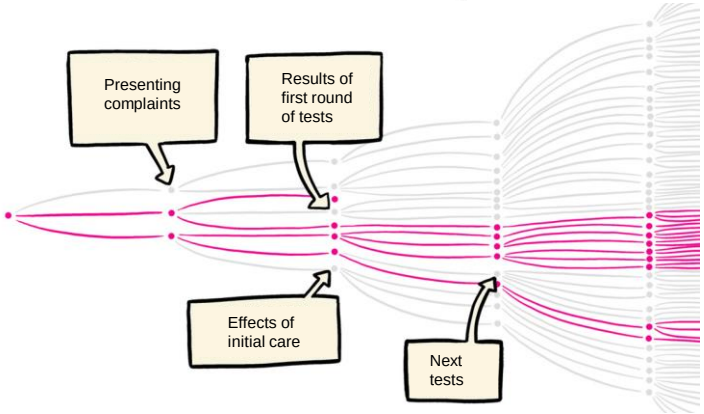
Technical problems

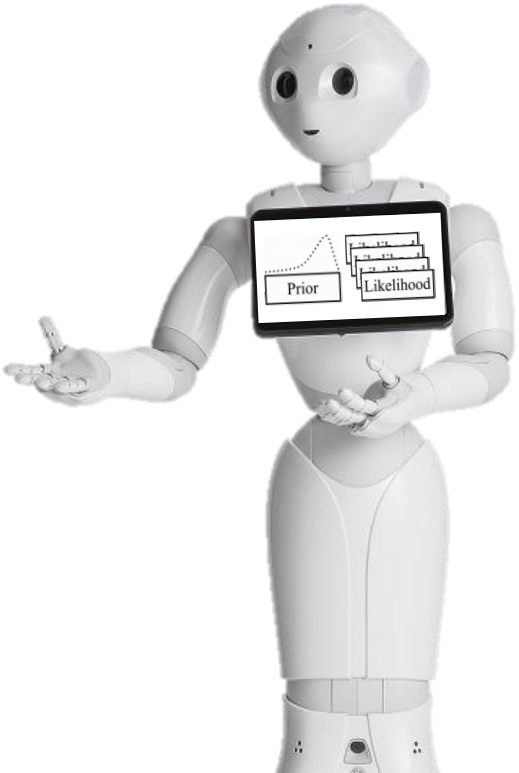
- Hard to get into healthcare data systems,
- Hard to understand data structures and missingness mechanisms,
- Hard to get access to images, ECGs, etc.
- Demands on CE-marking according to the EU Medical Device Regulation prohibit fast development–testing cycles.



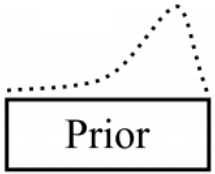
ML problems: Multiple kinds of massively missing data





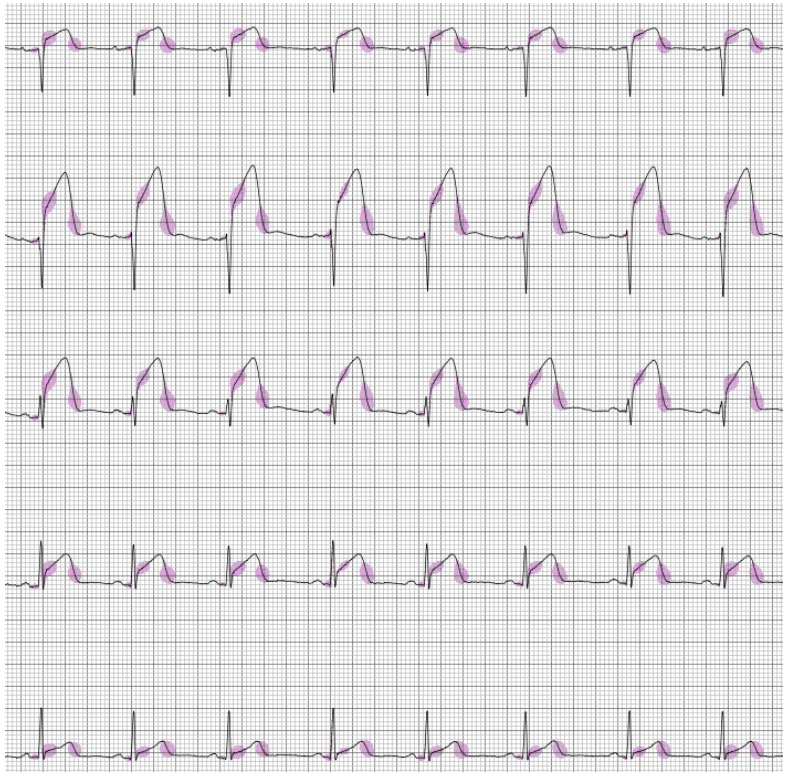


Solution: Bayesian approaches



Produce underlying risk estimates for all and updated estimates for some

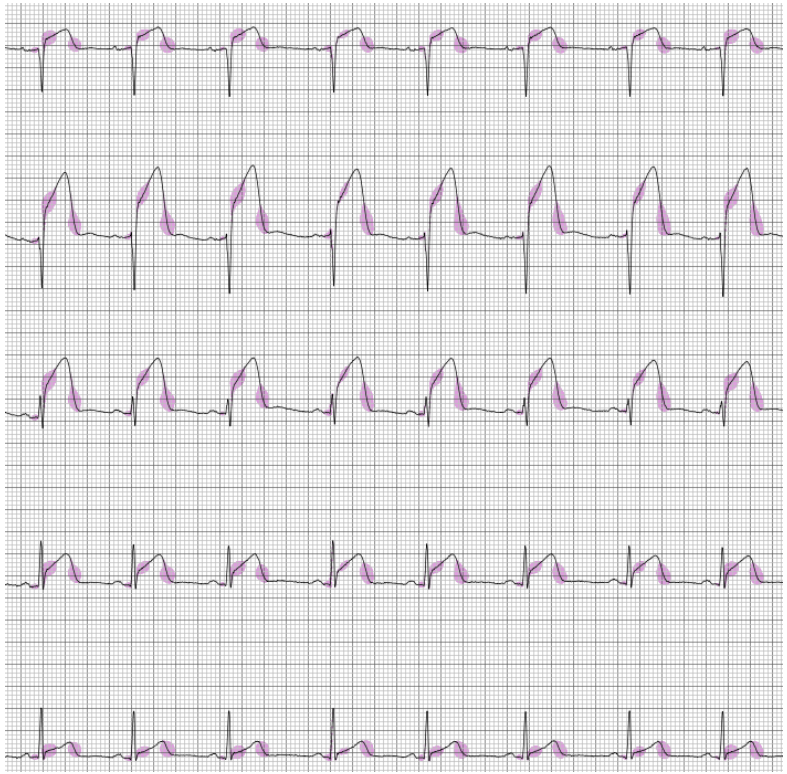
Novel data types



- Super-human-level performance in diagnosing heart attacks.
- The AI now teaches us humans to read ECGs.

Gustafsson et al, Sci Rep 2022;12:19615

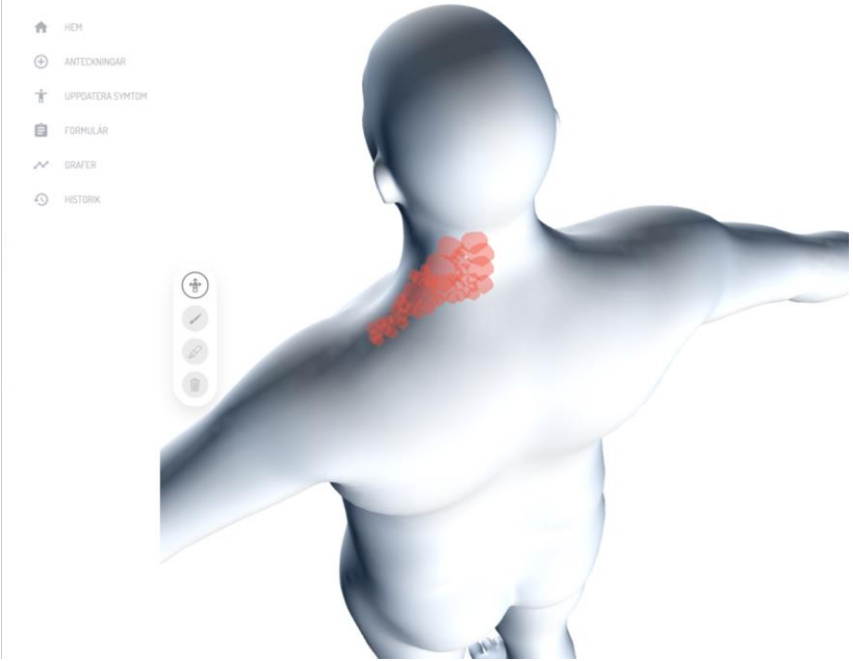
Novel data types

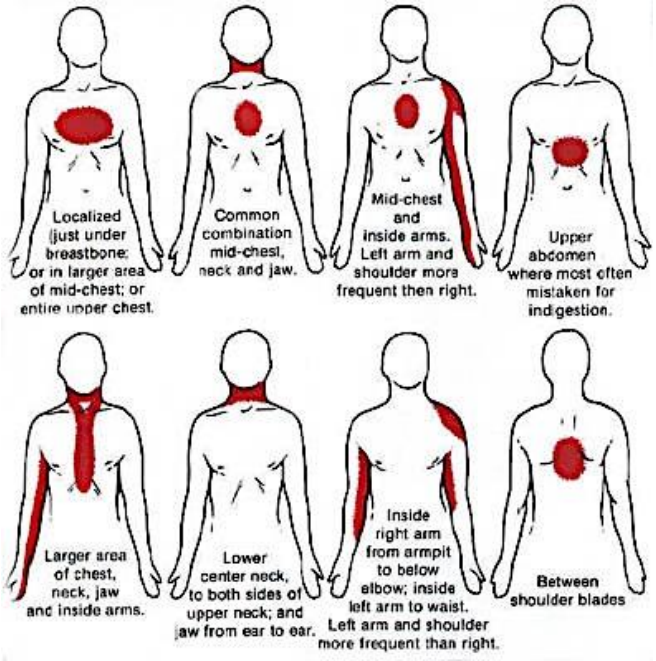


- Heart failure?
- Chronic obstructive pulmonary disease?
- Stroke?
- Pulmonary embolism?
- Acute aortic syndromes?
- Gastric ulcer?
- Gallstones?
- Pancreatitis?

Gustafsson et al, Sci Rep 2022;12:19615

Novel data types





The potential clinical gains by this research program are unequivocal:

- It has the potential to affect *rising costs* and *high misdiagnosis rates* in the ED, saving both money and lives.

The potential scientific gains are much more far-reaching:

- We will address two important developmental goals: handling missing data, and incorporating multiple kinds of data.
- Capturing entirely new varieties of patient-generated data, and using them to predict disease, is a massive developmental step for e-health (also outside of the ED). I propose calling it *symptomics*.

Ethical aspects

Ethical aspects raised by the ERC ethics panel

HUMANS

1. Detailed information on the informed consent procedures for research participants.
2. Project-specific templates of the information sheets and informed consent/assent forms (in language and terms understandable to the participants) with all relevant information regarding the protection of personal data, including the DPO contact details for host institutions required to appoint a DPO under the General Data Protection Regulation 2016/679.
3. Description of procedures to assess the decision-making capacity of the research participants in order to ensure that the informed consent procedures are adapted to their capacity.
4. Clarification whether vulnerable individuals/groups will be involved, and, if so, adequate measures to protect them, prevent coercion and undue inducement, exacerbation of their vulnerability, and minimise the risk of harm and/or stigmatisation.
5. Description of incidental/unexpected findings procedures and related disclosure policy.
6. Copies of opinions/approvals by ethics committees and/or competent authorities for the research with humans together with the full application(s).
7. For each clinical study (as defined by the Clinical EU Trial Regulation), information about the registration of the clinical study in an EU clinical trial registry (within EU) or WHO ICTRP or ICMJE- approved registry (outside the EU).

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Ethical aspects raised by the ERC ethics panel

PERSONAL DATA

8. Description of the technical and organisational measures to safeguard the rights and freedoms of the data subjects/research participants.
9. Description of the security measures to prevent unauthorised access to personal data or the equipment used for processing.
10. Description of the anonymisation/pseudonymisation techniques, and in case personal data are not to be anonymized/pseudonymized, a justification for not anonymizing/pseudonymizing the relevant data.
11. For personal data to be transferred from the EU to a non-EU country or international organisation, a justification that such transfers are in accordance with Chapter V of the General Data Protection Regulation 2016/679.
12. Detailed information on the informed consent procedures related to the processing of personal data.
13. For research involving profiling, an explanation on how the data subjects/research participants will be informed of the existence of the profiling, its possible consequences, and how their fundamental rights will be safeguarded.
14. For the further processing of previously collected personal data, documentation confirming that the beneficiary has the lawful basis for data processing and that the appropriate technical and organisational measures are in place to safeguard the rights of the data subjects.
15. Evaluation of the ethics risks related to the data processing activities of the project, together with an opinion if a Data Protection Impact Assessment (DPIA) should be conducted under art. 35 of the General Data Protection Regulation 2016/679, and if applicable, the DPIA.
16. Details on how patients' data using the "patient-centred technical platform" will be secured including clarifications on the role of ICT subcontractors vis-a-vis ethics issues.

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Ethical aspects raised by the ERC ethics panel

ARTIFICIAL INTELLIGENCE

17. Human right impact assessment covering the development, deployment and post- deployment phases, including detailed information on how respect for fundamental human rights and freedoms will be ensured (human dignity, right to privacy and data protection, right to health, right to be free from discrimination).
18. Detailed explanation on the measures taken to prevent/avoid potential bias, discrimination and stigmatisation in input data and algorithm design and outcomes.
19. Detailed explanation on how the research participants and/or end-users will be informed about:
    1. their interaction with an AI system/technology;
    2. the abilities, limitations, risks and benefits of the AI system/technique;
    3. the manner in which decisions are taken and the logic behind them.
20. Assessment of the ethics risks related to the AI and the measures set in place (risk mitigation plan) to prevent/mitigate any potential negative personal impacts during the research, deployment and post-deployment phases.
21. Explanation on how humans will maintain meaningful control over the most important aspects of decision-making process in the use of the Visual clinical decision support tool.

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Ethics Issue	Requirement	Category
Artificial Intelligence	A human right impact assessment (HRIA) covering the development, deployment and post-deployment phases, including detailed information on how respect for fundamental human rights and freedoms will be ensured, must be provided. Number of months to fulfill the requirement after the project starts: **18**	Deliverable
Artificial Intelligence	A detailed explanation on the measures taken to prevent/avoid potential bias, discrimination and stigmatisation in input data and algorithm design and outcomes must be provided. Number of months to fulfill the requirement after the project starts: **18**	Deliverable
Artificial Intelligence	The beneficiary must evaluate the ethics risks related to the AI and describe the measures set in place to prevent/mitigate any potential negative personal/social/environmental impacts during the research, deployment and post-deployment phases. Number of months to fulfill the requirement after the project starts: **18**	Deliverable

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