

From Digitally Supported Healthcare to Data-Driven Decision Making: the Role of Health Informaticians

Nadia Davoody, Stefano Bonacina, Sabine Koch

Nadia Davoody, Associate Professor, Health Informatics Centre, Department of Learning, Informatics, Management and Ethics, Karolinska Institutet, Stockholm. Email: nadia.davoody@ki.se
Stefano Bonacina, PhD, Health Informatics Centre, Department of Learning, Informatics, Management and Ethics, Karolinska Institutet, Stockholm. Email: stefano.bonacina@ki.se
Sabine Koch, Professor, Health Informatics Centre, Department of Learning, Informatics, Management and Ethics, Karolinska Institutet, Stockholm. Email: sabine.koch@ki.se

The healthcare sector generates large amounts of data from heterogeneous sources. The increasing use of data and analytical tools enables personalized medicine, predictive diagnostics, preventive care, and remote monitoring. Despite this potential, the shift towards data-driven healthcare faces significant challenges. The Joint Master's Programme in Health Informatics, offered by Karolinska Institutet and Stockholm University since 2010, equips students to meet these challenges by providing interdisciplinary competencies. As Sweden's only English-taught master's programme in health informatics, open to both domestic and international students, it attracts approximately 600 applicants annually for 40 study spots, and 346 students have graduated from the programme as of 2025. Thesis projects have progressed from electronic health record design and evaluation to interoperability, remote monitoring, secondary data use, predictive analytics, artificial intelligence, and precision medicine. Continuous alignment with healthcare and industry needs ensures graduates are prepared for the demands of data-driven healthcare.

Introduction

The healthcare sector generates large amounts of data from heterogeneous sources, including electronic health records, laboratory information systems, imaging modalities, sensors, patient-reported outcomes, health surveys, clinical trials, and administrative records [1]. In recent years, the healthcare landscape has undergone a significant transformation, driven by the rapid growth of digital technologies, allowing for digitally supported healthcare services and the increasing volume of health-related data, allowing for more informed, data-driven decision making, often conceptualized as data-driven healthcare. This digital transformation has opened new frontiers in personalized medicine, predictive diagnostics, preventive care, chronic disease management, and remote patient monitoring [2]. The integration of electronic health records (EHRs), clinical decision support systems (CDSS), wearable devices, predictive analytics, and artificial intelligence (AI) enables a deeper understanding of individual health trajectories and population-level health trends [3]. Data-driven healthcare enables the transformation of complex health data into actionable insights, supporting early diagnosis, personalized treatments, and proactive care. Integrating new technologies in health data analysis such as AI and real-time analytics, can improve decision-making, reduce errors, and lower costs, ultimately enhancing both patient outcomes and system efficiency [4-6].

Despite this transformative potential, the implementation of data-driven innovations faces several significant challenges. One major barrier is the fragmentation of health information systems and the lack of interoperability across clinical, administrative, and technological domains [1]. Healthcare IT infrastructures have long struggled to manage the volume, velocity, variety, and veracity of healthcare data, particularly due to inconsistent metadata and clinical coding [7-9]. Differences in data formats, disconnected health information systems, and varying terminologies, along with weak alignment and missing standards, make it challenging to integrate information smoothly and perform analyses that generate meaningful insights. These issues are intensified by the absence of unified governance frameworks, which hinders the aggregation and effective use of health data across settings [1]. Moreover, ethical and legal requirements, including the General Data Protection Regulation (GDPR), patient privacy, and appropriate consent models, must be handled with particular care, as they can constrain data sharing and the adoption of AI-based tools; recent EU developments such as the European Health Data Space (EHDS) and the AI Act further shape these obligations across jurisdictions [10-16].

Organizational readiness is a prerequisite for the implementation of health information systems. Many healthcare institutions lack the structural and cul-

tural capacity to fully embrace data-driven innovations. Digital health initiatives frequently fail to deliver sustainable impact due to poor integration with clinical workflows, inadequate alignment with healthcare professionals' needs, poor usability, and insufficient engagement with frontline users. The introduction of new technologies may disrupt existing clinical workflows, increase cognitive load for healthcare professionals, and lead to digital fatigue if not thoughtfully integrated into everyday practice [17-19].

Crucially, these challenges are sociotechnical rather than purely technical. Implementing successful digital health solutions requires a deep understanding of clinical workflows, care delivery models, patient-provider interactions, organizational cultures, and regulatory environments. Yet, too often, digital health solutions and data-driven innovations are developed in isolation from the realities of clinical care, resulting in tools that are poorly adapted to their intended settings and users [20,21].

This paper aims to present how the Joint Master's Programme in Health Informatics is designed to prepare students for these challenges. The programme integrates perspectives from medical and health sciences, computer science, and social science to help students develop the competencies needed to support data driven improvements in healthcare and to contribute to safe, accessible, efficient, and person-centred care.

Role of Health Informaticians

Addressing these complex, multidimensional challenges demand professionals who can operate at the intersection of technology and clinical practice. Health informaticians, with expertise bridging clinical practice and information technology, act as vital intermediaries. They communicate effectively with clinicians and researchers as well as system developers, information architects, and analysts, serving as translators and integrators of knowledge across disciplines. Their unique role involves not only designing and evaluating digital tools but also ensuring that such tools fit within complex clinical environments. They translate clinical needs into specifications and requirements for informatics solutions, making sure that digital tools are not only technically sound but contextually appropriate and user-centered [22,23]. They contribute critically to data governance in the areas of standardizing data, facilitating semantic interoperability, maintaining scalability, and safeguarding ethical standards. Furthermore, health informaticians play an essential role in validating AI tools and mediating among competing priorities to translate complex data into actionable knowledge [24].

As emphasized by Amri and Abed [3], the future success of data-driven healthcare will depend not only on technological innovation but also on professionals who understand clinical environments and digital ecosystems. The importance

of such roles has been recognized in competency frameworks developed by the American Medical Informatics Association (AMIA) and the International Medical Informatics Association (IMIA), which emphasize interdisciplinary training across health sciences, data analytics, systems thinking, and implementation science [25-27]. Building on these frameworks, the rapid evolution of data-driven healthcare, along with its associated challenges, including standardisation, digital infrastructure, interoperability, data visualisation, implementation, and governance, combined with the growing demand for integrating data and digital technologies into clinical practice, underscores why these competencies are no longer optional but essential.

Joint Master's Programme in Health Informatics

The joint master's programme in health informatics, launched in autumn 2010, is a two-year, full-time, campus-based interdisciplinary programme jointly offered by Karolinska Institutet (KI), Department of Learning, Informatics, Management, and Ethics, and Stockholm University (SU), Department of Computer and Systems Sciences. This unique collaboration bridges healthcare, information technology, and data science, equipping students with the skills needed for advanced careers in digital health. In Sweden, this is the only international master's programme in health informatics. We expect students who complete the programme to be able to design, implement, and evaluate digital health solutions; analyse and interpret health data to support evidence-based decision-making; contribute to and lead data-driven improvement initiatives; and collaborate effectively with clinical, administrative, and technical stakeholders to improve healthcare.

The programme syllabus was revised in 2012 and in 2017, guided by the IMIA competency framework [26]. The 2010 version of the programme was structured over four semesters, beginning with bridging courses that provided students from healthcare and technical backgrounds a shared foundation in health informatics, including computer and systems science or medical fundamentals, depending on prior education. Students then specialized based on their chosen track. The clinical track included project management and IT implementation, while the technical track focused on advanced health information systems and interoperability, and later, machine learning. All students also studied courses such as case-based modelling, research methodology, and simulation, concluding with a 30-credit degree project. The 2012 revision retained the bridging semester but removed the track structure, allowing all students to take the same courses regardless of background. The second semester focused on basic knowledge and skills in health informatics, including user-needs modelling, evaluation methods, standards, and project work. The third semester introduced methods for clinical

decision support, modelling, simulation, and visualization in health informatics, alongside a large block of elective courses enabling students to tailor their profile or study internationally. The fourth semester was reserved for the degree project. The programme outcomes emphasised broad and specialised knowledge in health informatics, methodological competence, ability to handle complex phenomena, and capacity for both research and professional work.

Since 2017, the programme aimed at better preparing students for data-driven healthcare. The updated curriculum introduces a dedicated course in data science, ensuring that students develop the technical competencies required to analyse and interpret healthcare data effectively [28]. Greater emphasis is placed on standardisation and interoperability, giving students a stronger foundation in applying consistent frameworks across different digital health information systems. The programme also incorporates emerging topics such as information security, entrepreneurship in the digital society, and current research and trends in health informatics, aligning the curriculum with the rapidly advancing digital health landscape and its related sociotechnical aspects. Collectively, these changes aim to equip graduates with the competencies needed to drive innovation and support effective, data-driven healthcare. Figure 1 shows the organization and flow of courses within the Joint Master’s Programme in Health Informatics, highlighting their connections to health sciences, computer sciences, and research.

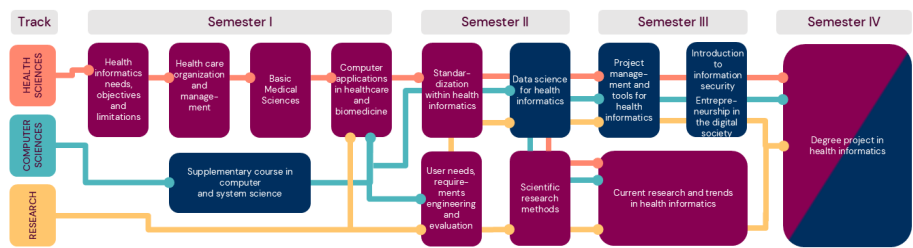


Figure 1. Overview of the course flow in the Joint Master’s Programme in Health Informatics. The figure also show how courses are connected to health sciences, computer sciences, and research. A dot at the end of a line represents a connection between the track and a specific course. Courses shown in purple are offered by KI, while courses in blue are offered by SU.

Programme growth and admissions

Since the programme started, spanning 2010 to 2025, 346 students have graduated. Currently, the program attracts approximately 600 applicants worldwide, competing for 40 available study places each year. Over the past four years, the number of applicants to the Master’s Programme in Health Informatics has steadily increased, rising from 465 in 2022 to 627 in 2025, reflecting growing

interest in the programme. Applicants come from heterogeneous professional backgrounds, including healthcare and medicine, engineering, system development, and design. This diversity is central to the programme's approach, fostering multidisciplinary collaboration to address complex challenges in health informatics. Students come from Sweden as well as other European countries including Germany, Spain, and Italy, and from countries in Asia and Africa, such as China, India, Malaysia, Indonesia, Myanmar, Nigeria, Kenya, as well as from the Americas and the Middle East.

Graduates pursue careers both in Sweden and internationally, working across diverse sectors such as healthcare, research, private industry, governmental organizations, and public health agencies. Their roles are equally varied and include positions such as health informaticians, data scientists, product owners, global regulatory affairs managers, researchers, lecturers, digital healthcare safety and regulation leads, medical content developers, information architects, requirement analysts, solution architects, chief medical/clinical information officers, digital transformation leads, clinical terminology leads, information security leads, system interface analysts, information technology (IT) consultants.

Research and thesis work

The master's thesis projects developed within the Joint Master's Programme in Health Informatics reflect the changing demands and developments for data-driven healthcare. Early projects primarily addressed topics such as the design and evaluation of electronic health records or digital tools. Over time, the focus expanded to encompass areas including standardisation and interoperability, remote patient monitoring and teleconsultations, secondary use of health data, advanced data analytics, predictive diagnostics, artificial intelligence in healthcare, personalized medicine, and chronic disease management. This progression underscores the critical role of health informaticians in building and developing the digital and analytical infrastructure essential for contemporary healthcare systems. Table 1 illustrates how the topics of the thesis projects in the programme have evolved over more than a decade to address emerging challenges and meet the growing demands of data-driven healthcare.

Table 1. Overview of the thesis areas and their relation to data-driven healthcare. Acronyms: Artificial Intelligence (AI), Electronic Health Record (EHR), Machine Learning (ML), Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT).

Period	Main focus areas in theses	Examples of topics/representative themes	Relation to data-driven healthcare
2012 -2013	Design and evaluation of digital tools, EHRs, and clinical decision support systems, patient-centered care	Evaluation studies, virtual patient simulations, workflow integration, data and information exchange	Early phase of digital transformation, focusing on needs assessment, improving usability, and exploring implementation in existing infrastructures in high- as well as low-and-middle income countries
2014 – 2016	Standardization and interoperability, information and workflow modelling, secondary use of data	Using EHR data for research, data harmonization, multilevel data modelling, image analysis and text mining of clinical notes	Growing interest in structured and standardized data for both primary and secondary use, and early steps toward creating interoperable information systems
2017-2019	Predictive modelling, clinical decision support, process automation	ML for diagnosis and prognosis, AI for infection detection, and digital workflow optimization	Increased analytical focus, applying data science and AI to clinical contexts
2020-2022	Telehealth, consumer health informatics, interdisciplinary collaboration, and secondary use of data	Remote video consultations, collaboration tools, ethical aspects, and data security	Integration of digital health information systems for person-centered care, early steps towards the health data space
2023-present	Machine learning, multimodal data integration, AI, precision medicine, National information models	AI for disease prediction, ML fairness, predictive modelling, multimodal ML for oncology and obesity, Terminology mapping, and semantic interoperability frameworks.	Reflects a data-driven perspective, focuses on precision medicine, AI-enabled decision making, explainable AI, and secondary use of health data to optimize healthcare delivery, support clinical research, and improve patient care

Contribution to the field and expected competencies

The collected theses provide a broad spectrum from digital health solutions to data-driven healthcare and address critical challenges in precision medicine, clinical decision-making, workflow efficiency, information exchange, user-centered design, patient engagement, and ethical data use. These areas align closely with the competencies highlighted in recent literature [29-33]. A strong emphasis is placed on design and evaluation, with usability studies of electronic

health records, virtual reality interfaces, mobile health applications, and remote consultation services. These studies apply user-centered design and stakeholder feedback to ensure that digital solutions are practical, safe, and effective. According to previous research [26], these competencies have been recognized as essential for guiding the design and implementation of digital health solutions.

Digital and remote health innovations form another major focus, including telemedicine, mobile applications, virtual reality tools, conversational agents, and remote monitoring systems. These technologies aim to improve usability, accessibility, and patient-centered care. In parallel, significant efforts focus on advancing standardization and interoperability through structured data models, OpenEHR archetypes, and integration of dental and medical records. These initiatives enhance semantic alignment and cross-system data exchange, thereby improving clinical workflows and supporting evidence-based care. Competencies in these areas are consistently emphasized in prior research [29-31].

Artificial intelligence and machine learning are also explored to improve interpretability, diagnostic accuracy, and precision medicine. Data privacy, security, and ethical considerations remain central across multiple projects, including evaluations of privacy policies in mobile health applications and frameworks for AI-driven predictive models. Developing competencies in these areas is considered essential by previous studies [30,32].

Concluding remarks

Considering the opportunities and challenges of data-driven approaches in healthcare, universities play a crucial role in preparing future health informaticians with the competencies needed to succeed in this rapidly evolving field. Equally important is the continuous assessment of healthcare organizations and industry stakeholders' expectations and needs to stay aligned with the changing demands of the healthcare sector. Insights from such evaluations can inform the development and revision of educational programs, ensuring that curricula remain consistent with real-world requirements. By fostering strong connections between academia, healthcare practice, and industry, educational institutions can equip professionals to lead innovation and address the complex challenges of future healthcare systems.

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