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Clarifying the relationship between biomedical and health informatics and digital health: expert perspectives

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ABSTRACT

The rise of digital health (DH) has sparked debates about its relationship with the long-established field of biomedical and health informatics (BMHI), with some questioning the need for new academic programmes in DH since much of the likely content is already covered in BMHI training programmes. At the International Medical Informatics Association panel, 'Shaping the Future of Biomedical and Health Informatics in the Digital Health Era' (MEDINFO 2025), only one-third of participants clearly distinguished the two fields, highlighting conceptual ambiguities and the influence of DH narratives. This article compiles the perspectives expressed by the panellists, all experienced BMHI scholars, presenting their distinct viewpoints on how the field can maintain its scientific identity while engaging with emerging DH initiatives.

INTRODUCTION

The recent rise of digital health (DH) has generated widespread attention and raised questions about its relationship with the long-established field of biomedical and health informatics (BMHI). Calls for dedicated DH degrees[1] have sparked debates within the biomedical informatics community, with some experts questioning the need for programmes that BMHI already largely covers.[2] This reflects a common misconception: stakeholders perceive a gap in academic offerings that, in reality, does not exist. Rather than challenging BMHI's legitimacy, these debates reveal conceptual ambiguity about whether DH constitutes a distinct field or a rebranding of well-established BMHI methods, tools and infrastructures.

In this context, the International Medical Informatics Association (IMIA) convened a panel titled 'Shaping the Future of Biomedical and Health Informatics in the Digital Health Era' at the MEDINFO 2025 conference organised in Taipei (Taiwan).[3] At the start of the panel, the audience was asked whether they considered DH as merely a fancy term for BMHI. Only one-third of participants clearly distinguished the two fields, highlighting both the conceptual blurring between them and the growing influence of DH narratives, which often overlook decades of foundational work in BMHI.

The panel provided a forum for critical reflection on BMHI's disciplinary positioning amid the rapid digital transformation of healthcare. Senior scholars, pioneers and thought leaders discussed how BMHI can maintain its scientific identity while engaging with emerging technological, industrial and policy-driven DH initiatives.

This article compiles and contextualises the perspectives expressed by the panellists, presenting their distinct viewpoints informed by decades of experience in BMHI research, education and leadership. These perspectives reflect diverse epistemologies, disciplinary traditions and strategic visions. Rather than seeking consensus, this compilation preserves the plurality of viewpoints, acknowledging that the evolution of BMHI in the DH era is neither linear nor univocal. As such, the paper can be considered as a companion of Séroussi's paper, 'Beyond the Digital Health Tsunami: Reaffirming Biomedical and Health Informatics as the Scientific Foundation of Digital Healthcare Transformation'.[4]

By presenting these perspectives within a single narrative, the article illuminates the complexity of the ongoing debates and provides readers with multiple analytical lenses to interpret the relationship between BMHI and DH. The contributions aim to stimulate critical reflection, support informed alignment with the perspectives presented and foster a clearer understanding of the respective roles and relationships between BMHI and DH. More broadly, this dialogue seeks to encourage continued discussion within the BMHI community regarding disciplinary identity, scientific foundations, translational

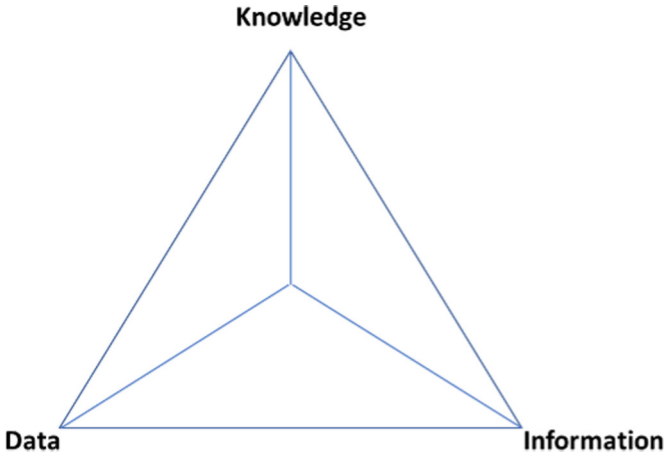

Figure 1 The data–information–knowledge triangle.

responsibilities and governance in an increasingly digitalised healthcare ecosystem.

PERSPECTIVE FROM PATRICE DEGOULET

The title of the IMIA panel comprises three expressions: medical informatics, health informatics and DH. But before entering the discussion, let me make a preliminary comment on what I believe is a reductionist representation. We frequently build our field over a data–information–knowledge pyramid, with data at the bottom and knowledge at the top. Data generate information that leads to knowledge. But we could invert this pyramid and consider that everything is built around knowledge. Knowledge is necessary to understand the meaning of data and to extract information from it. Genius scientific intuitions or prophets' revelations belong to knowledge without being necessarily proved at instant *t*. Current generative artificial intelligence (AI) tools can generate false knowledge and fake data/information (news) from speculative knowledge. I therefore believe that we should replace these two pyramids by a triangle with data, information and knowledge at each corner, and links between them (see figure 1), in the manner of Ogden and Richards with their semiotic triangle.[5]

Let us focus now on the meaning of the medical informatics expression. The German term 'Informatik' first appeared in 1957 in a book by Steinbuch (1917–2005).[6] The French term 'Informatique' was proposed in 1962 by the French engineer Philippe Dreyfus. 'Informatique' was defined as the science of information and its processing with computer tools. Medicine is both a science and the art of managing patients' diseases. François Grémy initiated the IFIP (International Federation for Information Processing) – Technical Committee 4 (TC4), entitled Medical Information Processing, in 1967. The expression 'Medical Informatics' spread across all continents. The first world meeting on medical informatics, MEDINFO, was held in 1974 in Stockholm, with Grémy as SPC (Scientific Programme Committee) chair, while IFIP-TC4 became IMIA. To summarise, medical informatics is built around three dimensions: science, medicine and information processing. The data and knowledge dimensions of our triangle are skipped or considered implicit. The data science and knowledge engineering expressions are useful complements.

The appearance of the expression health informatics coincides with that of medical informatics in the 1970s. Health is a human target and a subset of happiness. WHO provided its initial definition of health in 1946, but forgot to define the term 'disease', which indeed changed quickly as we gained better omics and environmental knowledge. The action dimension of medicine is skipped, whereas it would not be the case with the expression healthcare informatics.

The DH expression appeared as a buzzword in the mid-1990s, naturally supported by the computer industry and health governance organisations such as WHO and OECD (Organisation for Economic Co-operation and Development).[7] DH is a popular but curious association. Most physiological processes are analogue, and the analogue-integrated circuit market is experiencing rapid growth. DH is therefore a subset of electronic health or eHealth. The action dimension of medicine is skipped, unlike in the digital healthcare and the e-Healthcare expressions.

Indeed, finding the proper expression to express our scientific field is a tricky issue. Shorter expressions are better than longer ones. In two-word expressions, the noun word expresses the gravity centre. The exact meaning depends on the language. Any added adjective or prefix/suffix to a noun reduces the meaning of the expression. Biomedical is weaker than medical, and global health is weaker than health. The expression 'Biomedical and health informatics' is long and redundant, as it combines a compound adjective with two nouns.

My personal experience with expressions illustrates this point. François Grémy initiated a curriculum on the applications of informatics in medicine in 1967. This curriculum was part of a broader curriculum including statistics and biomathematics. When Grémy left Paris for Montpellier in 1984, I took the lead of a consolidated 'Master's Degree in Medical Informatics'.[8] In 1997, the master's degree was renamed 'Biomedical Informatics' to attract biologists, engineers, physicians and nurses interested in medical informatics. Both medical, biomedical and bioinformatics master's degrees coexist in France today. My research laboratory was successively named 'Medical Informatics' in 1998, 'Public Health and Medical Informatics' in 2000 and 'Knowledge Engineering and eHealth' in 2007. Constantly changing names just adds complexity to the complexity.

To conclude, I am proud and happy to see the 50-year continuity of the medical informatics field because it has, through IMIA, supported a global network of scientific professionals. Outside of this example, I am in favour of short, pervasive, carefully selected and context-dependent expressions. I must confess that such a recommendation is hard, if not impossible, to follow, that is, since we try to

express in intension what we hardly express in extension with a large set of words.

PERSPECTIVE FROM EDWARD HANCE SHORTLIFFE

The question of naming in our field is not merely technical; it is also deeply emotional and sociological. Each change of terminology reflects the evolution of our scientific identity and, to some extent, the maturation of our collective consciousness as a community. I have personally lived through many of these transitions, and the story of our nomenclature offers valuable insight into how we arrived at today's debate on DH.

When I first discovered this field as a medical student in the early 1970s, fascinated by computing and its potential in medicine, there was no accepted name for what I was studying. At Stanford Medical School, I worked with faculty advisors to create a joint degree in medicine and computing, eventually earning a PhD through an innovative programme that allowed me to name my own degree. In the absence of a well-accepted term for the field, I called it *Medical Information Sciences* (MIS), a term of necessity rather than consensus, but one that intentionally avoided explicit mention of computers. Early in my faculty career, a senior colleague advised me that my academic success would likely depend on whether colleagues came to see my work as new science rather than as programming or straightforward system building. That advice proved formative: from that moment, I made it a central mission to demonstrate that our work offered the kinds of new and generalisable knowledge that constitute scientific contributions, emerging from a discipline with its own methods, theories and epistemology, not just a set of technical tools.

When the term *informatics* broadly appeared in the late 1970s, I was attracted by its rapid acceptance and by its avoidance of computer or programming terminology in the title. Although we maintained the MIS name for our Stanford degree for practical reasons of consistency, we also established a Section on Medical Informatics in the Department of Medicine, emphasising scientific inquiry over pure engineering. While tool development was part of our activity, the focus remained on generating new knowledge about knowledge, reasoning and information processes in medicine. By the 1980s and 1990s, as technology advanced, computing power increased, memory shrank in physical size while growing dramatically in dense storage capacity, networks proliferated and the internet became ubiquitous, our field naturally expanded. Simultaneously, the Human Genome Project[9] gave rise to *computational biology*[10] and later *bioinformatics*,[11] as biologists recognised the need for computational methods similar to those used in clinical informatics. Yet, despite methodological parallels, these communities developed largely in isolation. We realised the need for bridges between molecular biology and clinical care, between the 'bio' and the 'clinical'. Of course, this synergy was later made even more explicit with the emergence of precision medicine.

The convergence of the clinical and bio worlds inspired, around the year 2000, the adoption of the term *Biomedical Informatics* (the second edition of our informatics textbook, published in 2000, transitioned its title from *Medical Informatics* to *Biomedical Informatics*, which has been used in all subsequent editions[12]), acknowledging the unification of biological, clinical and population-level perspectives. By then, organisations such as the American Medical Informatics Association had already solidified their identities, so they kept their established medical informatics names but increasingly used 'biomedical' to reflect the expanded scope. Soon, colleagues in public health emphasised the population dimension, advocating for the term BMHI to represent the full spectrum, from molecules to individual human beings to populations.

Over the last 15 years, the rise of mobile and connected technologies, wearables, smartphones and embedded sensors has given birth to what is now being called DH. This application focus has generated tremendous enthusiasm among our students and professionals, as they see novel tangible opportunities to improve care and patient experience. Many informatics programmes, including ours, have embraced this trend, creating courses and projects to prepare students for roles in DH innovation, typically in industry, health systems or other environments outside of academia. However, while I welcome the creation of dedicated master's programmes in DH to address these applied needs, I strongly reject the notion that DH should replace or rename BMHI. The latter remains the scientific foundation on which DH rests (see figure 2).

In essence, BMHI is the science that explains and underpins the technologies and data ecosystems driving DH. The two are intimately related but fundamentally distinct. DH is an applied expression, an engineering and implementation domain, whereas BMHI represents the core scientific discipline where research is performed and new knowledge is created. To conflate the two would be to fail to recognise the distinctions between the applied world and the underlying science that drives applications into new areas, using new methods. Therefore, I advocate maintaining the established terminology of our field while encouraging collaboration, cross-fertilisation and the creation of complementary training paths. There is certainly room for a master's degree in DH, training individuals for roles in the applied world, but renaming our science with an applied label would be, in my view, a categorical mistake.

PERSPECTIVE FROM CHRISTIAN LOVIS

In every scientific field, naming is both an act of precision and an act of existence. To name something is, in a sense, to bring it into being: to define, to delimit and to assign meaning. Yet naming is also an act of appropriation. Words matter profoundly. They enable us to describe

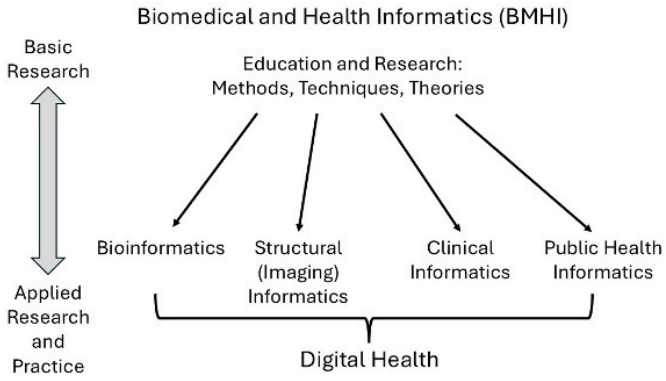

Figure 2 *Biomedical and health informatics* is the established name for science underlying the development of methods, techniques and theories that comprise our discipline. Those methods are developed in the context of applied projects that span from biological studies (bioinformatics) to those that focus on organ systems (structural or imaging informatics), those that focus on full human organisms (clinical informatics) and projects addressing the health of populations (public health informatics). With the growth and expansion of the applications of BMHI in areas related to human health, including those now depending on genetic and immunological topics in the area of precision medicine, we can view the new emphasis on *digital health* as embodying the applied work that spans all four application domains.

what we do, and they allow our work to be understood and recognised by others. In the history of our discipline, as Patrice Degoulet (PD) and Ted Shortliffe have already emphasised, terminology has not evolved by accident, but through its own history, by reflection and intention, thereby constructing a shared and communicable body of knowledge.

It is in this way that nursing informatics, public health informatics and bioinformatics, among others, have emerged, each seeking to articulate its own space within the broader landscape of BMHI. Although these subfields existed in essence well before they were named, their recognition as full-fledged entities was consolidated through their naming, along with the possibility, for many professionals, to identify their work with a clearly defined domain.

When I reflect on the contemporary enthusiasm for DH, I see a similar dynamic at play. If we examine the numerous definitions currently in circulation, what DH describes largely overlaps with what medical, biomedical or nursing informatics have practised for decades: evaluation, usability studies, patient engagement, clinical trials, implementation research and iterative testing, to name only a few. These are not novel activities but well-established dimensions of our field. The difference lies in visibility and acknowledgement. Those who concentrated on implementation rather than theoretical development—who experimented in real-world settings, failed, learnt and improved actual systems—have often been under-recognised. Similarly, colleagues who worked closely with patients, care processes and organisational change were sometimes perceived as peripheral to 'core' research in the field.

I would therefore argue that the rise of DH reflects less a conceptual revolution than a reality check: the need of the real world to build on translational research, the need for applied research and demonstrable impact and the desire of those involved to see their contributions explicitly named and valued. Naming continues to evolve along the same two axes: precision and creation. It is about securing existence and legitimacy within the scientific ecosystem. Our task, then, is not to defend terminology against change, but to shape it in an inclusive manner, ensuring that all contributors to the field, engineers, nurses, clinicians, data scientists, policymakers, patients and ultimately citizens, can recognise themselves within the field.

To illustrate this, in Geneva we have renamed our Certificate of Advanced Studies (CAS) in Medical Informatics as a CAS in DH, and we established, several years ago, a successful doctoral programme titled Genomics and DH. While the content of both initiatives is largely inherited from existing programmes in science and medicine, their governance has been reorganised in a more inclusive way, strengthening the collaboration between the Faculties of Science and Medicine, the nursing schools, among others. The term 'digital health' has functioned as a powerful attractor. It has provided legitimacy and visibility to professionals who previously felt that their scientific identity was undervalued. It has also helped to broaden the scope of bioinformatics, which risked becoming confined to traditional biomolecular and genetic informatics. The lesson, I believe, is that language can open doors, broaden participation and empower those who innovate from within practice.

However, increasing linguistic precision also carries the risk of overspecialisation. As the field expands, we tend to create ever finer distinctions, which can inadvertently lead to disciplinary silos. This mirrors a pathology well known in medicine itself: hyperspecialisation leading to fragmentation. We must avoid reproducing this phenomenon in our fields, whose future depends on interoperability between machines and interoperability between people. Only by maintaining active dialogue across specialisations can BMHI, in all its evolving forms, remain a coherent and vibrant scientific field.

PERSPECTIVE FROM WILLIAM ED HAMMOND

I think this discussion must begin with an understanding of what is fundamental and common to our discipline: information. Claude Shannon (Bell Labs, 1948) made information a science by giving it a unit of measurement—a bit. He predicted the information content of several things—a single page, a book, a floppy disk and even the Library of Congress. The focus was not on the data's form, but on the information itself. Information reduces uncertainty or disorder. Information is the gold standard of what we do. Information is the currency of

biomedical research, clinical care, public health and effective healthcare policies.

Words are important, and they can limit the scope of one's thinking. A diagnosis, for example, limits thinking to that particular disease and focuses our thinking on that disease. The perceived meaning of words is important to comprehend the truth.

The panel assignment was to discuss BMHI and DH, and how we might navigate both in an area increasingly shaped by DH. For me, these terms are not competitive. My career evolved from electrical engineering to biomedical engineering to health informatics. I now refer to myself as an informatician. For me, biomedical engineering is the broader term and includes DH as a topic it addresses. The word Health replaced Medical to imply the field included wellness care. As more of health and healthcare became digitised, we introduced the term DH. In a broader sense, we use different modifiers before the word 'Health' to draw specific inferences. We now have AI Health, Mobile Health, Virtual Health, Population Health, Home Health and an increasing number of other areas of focus. BMHI, in my opinion, is the discipline that includes all these terms.

Biomedical informatics is an interdisciplinary field that draws on engineering disciplines, including control systems, computer science and information technology, to use data to understand, manage and enable better healthcare, clinical care and research. It includes converting data into knowledge and acquiring, storing, processing and analysing biomedical data. Areas of focus include clinical informatics, bioinformatics and biostatistics. It includes developing mobile devices, wearable devices, imaging systems, waveforms and other analogue signals, as well as sounds, percussion, colours and other forms of data. Biomedical informatics includes integrating data from multiple sources, supporting data transfer and developing standards, terminology, algorithms and application programming interfaces.

DH is the convergence of digital technologies with health, healthcare, research and society. It includes technologies, platforms and systems that engage consumers for lifestyle, wellness and health-related purposes. It makes care and treatments more personalised and precise. It means capturing high-quality, relevant data with consistency. It enables the delivery of the right data to the right person at the right place, at the right time, for the right purpose. It permits the use of appropriately localised and personalised data. DH can and should act as a force multiplier for innovation to address challenges for individuals and population health. DH can ensure that equitable care is available for all (modified from Wikipedia).

DH uses mobile telecommunications to deliver health and healthcare information in support of wellness. It includes personal wearable and internal devices as well as sensors in people, homes, cars, workplaces and communities. DH enables us to identify health risks and assist with the diagnosis, treatment and monitoring of health conditions and diseases. It complements the episodic data from people who are captured by current healthcare approaches. DH requires interoperability enabled by data standards, the integration of all data sources into a common, functionally singular database. Real-time data capture outside the traditional healthcare environment is required. Smooth integration of AI into the collection, integration and interpretation is essential.

We need to understand the hierarchy of words we use. The future will produce new focus and new terms. We need to establish and agree on the node of the hierarchy, and I think that includes the word informatics. For now, in my opinion, that word is BMHI. That provides a focus for identifying and solving other problems in the health and healthcare systems.

There remain unsolved problems in health and healthcare systems. One problem is the lack of a universal person identifier. Another problem is the lack of a single, global terminology or a set of common data elements that represent a single concept. The current mapping between multiple terminologies or common data models results in information loss, is mostly outdated and costs money. We need to focus on this and other problems that exist across all the named labels we use.

PERSPECTIVE FROM HEIMAR DE FATIMA MARIN

Nursing informatics is a vital part of our collective story, and our debate over terminology, whether to use BMHI or DH, is not merely a linguistic issue; it is profoundly cultural. Language reflects the values and structures of our societies; the words we choose influence who is acknowledged, who participates and who is marginalised.

Throughout my career, I have witnessed this interplay of language, culture and recognition many times. I began as a nurse specialising in obstetrics before pursuing a master's and PhD in health informatics. In Brazil, we initially adopted the term 'health informatics' as our primary designation, while some universities preferred 'medical informatics'. The choice often revolved less around science and more around representation: by having 'medical informatics', 'nursing informatics' and 'health informatics' as distinct entities, universities could establish three full professorships on the university council, thereby giving voice and power to multiple professional groups within academic governance. Names became instruments of inclusion, ensuring visibility and legitimacy across disciplines.

Later, when I was being trained in clinical informatics under Charles Safran's leadership at Harvard Medical School and returned to Brazil, I collaborated with colleagues like Lucila Machado to establish the first doctoral and master's programmes in nursing informatics. For 15 years, with the support from the US National Library of Medicine, we ran initiatives that extended to Brazil and several African countries. Interestingly, as our programmes gained recognition, physicians and other professionals began enrolling in what was formally called nursing informatics, not because they

wanted to study a topic that would be positioned as relevant only to nurses, but because they were eager to learn about interoperability, standards, system architecture and the practical aspects of health informatics. Eventually, we had to rename the programme to better reflect this interdisciplinary participation.

The question of terminology is particularly complex in Brazil, where biomedicine is a regulated profession. There are undergraduate and graduate degrees in biomedicine, and professionals known as biomedicals primarily work in laboratory analysis and pharmaceutical research. Using the term 'biomedical informatics' in our context risks confusion—just as 'medical informatics' once did, when it was wrongly assumed to pertain only to physicians. Thus, 'health informatics' became a more inclusive term, capable of encompassing nursing, nutrition, public health and other health professions.

Despite the proliferation of new technologies and terminology, we continue to face enduring challenges: data quality, information integrity and the centrality of the patient. Whether one organises knowledge as 'data–information–knowledge' or in reverse, the essential question remains how to ensure reliable, meaningful data that serve care and equity. In this sense, we echo the foundational concerns articulated by pioneers like Dr James Cimino[13 14] decades ago.

Recently, Brazil has begun to institutionalise DH, partly due to political opportunity. When the new government came into power, Dr Ana Estela Haddad, who holds a PhD in telehealth, was appointed to lead the newly created Secretariat of Digital Health. This provided an opening for our community to advocate for national DH policies. We contributed by submitting a framework of professional and academic competencies adapted from international standards,[15–19] which we are now promoting to the Ministries of Education and Health. Our aim is to ensure that DH competencies are recognised as essential for all health professionals, nurses, physicians, pharmacists and others, and that interdisciplinary collaboration becomes the norm rather than the exception.

From my perspective, health informatics must remain the foundation for DH. There can be no sustainable DH ecosystem without the rigorous structures of informatics, standards, interoperability and data governance. DH is directed towards citizens and patients, but to transform connectivity into care and turn an app or a sensor into something meaningful, we need the solid infrastructure of informatics. Health informatics provides the invisible architecture that makes DH possible. Ultimately, I view our relationship not as competitive but as symbiosis: DH brings visibility and reach, while health informatics provides depth, rigour and a scientific foundation. That, I believe, is the true partnership we must continue to develop.

PERSPECTIVE FROM YU-CHUAN JACK LI

I must begin by saying that I am probably a little bit on the younger side of this panel and thus have lived through fewer of the name changes that my colleagues have recounted. When I returned to Taiwan in 1995, however, I quickly discovered that public understanding of our field was limited. For nearly a decade, every talk I gave, whether to students, clinicians or policymakers, had to begin with the same question: what is medical informatics? I carried a single set of slides for years, repeating that definition over and over.

This experience taught me that naming is semantic and strategic. The words we use will determine whether people understand our work, support it and fund it. As editor-in-chief of the *BMJ Health & Care Informatics*, I recently witnessed this dilemma first-hand. The publisher proposed changing the journal's title to include 'Digital Health and AI' after extensive marketing research suggested the new name would attract more readers. The editorial board debated the issue for months and ultimately decided to retain the original title, only for BMJ to launch a new journal with the proposed name. The episode revealed that even within a single publishing house, terms like medical informatics, health informatics and DH are perceived as distinct markets. So, while they may overlap conceptually, in practice they carry different connotations and audiences.

For me, medical informatics remains primarily a research-driven field. It is about developing, validating and refining methods, theories and applications that improve medicine, nursing and the health sciences. Health informatics extends this perspective to include broader systems, often encompassing public health and community-level interventions. But the emphasis remains scientific, focused on generating and validating knowledge. In contrast, what many now call DH represents a larger and more applied umbrella. It involves not only the technical or clinical aspects of implementation but also business models, regulations, market feasibility and sustainability.

To illustrate this distinction, I often reflect on a project we conducted more than a decade ago. We developed a wireless blood pressure monitor that automatically transmitted readings from patients' homes to the hospital's electronic record. When a patient returned for a visit, the physician could simply click a flashing button in the computerised order entry system and instantly view all home measurements. The patients were proud of their adherence; the doctors were pleased with the data; we published a paper, validated the concept and celebrated the success. Yet after 1 year, the project ended. The devices were university property and could not be sold, the maintenance infrastructure disappeared and the system was never integrated into routine care.

By academic standards, it was a success, a well-funded, well-published study that advanced knowledge. But from a DH perspective, it was a failure: the innovation was not sustainable, not scalable and not market ready. It lacked the regulatory and business components, such as Food and Drug Administration approval or commercialisation pathways, that are essential for transforming prototypes

into real-world solutions. This, to me, exemplifies the difference. Medical informatics aims to prove that something works; DH seeks to make it work at scale. Both are valuable, but they operate with different goals, constraints and metrics of success.

Therefore, while I fully agree with my colleagues that medical and health informatics constitute the scientific foundation for DH, I also recognise that DH occupies a distinct practical domain. It is more consumer oriented, easier to communicate to the general public and increasingly driven by private sector dynamics. Its terminology resonates with policymakers and industry partners in ways that 'informatics' does not.

In conclusion, I would not advocate renaming our entire discipline. Rather, I would propose a formulation that highlights the complementarity of the two spheres. If we must connect them explicitly, let us describe our field as 'Medical Informatics, the science that drives Digital Health'. This phrasing preserves our scientific identity while acknowledging the transformative potential of DH as its applied expression. Both are necessary: one to generate evidence, the other to translate it into impact.

PERSPECTIVE FROM OTTO RIENHOFF

In the last decade, the speed of change in optimising healthcare, research and teaching has constantly been growing. This leads to recommendations for a spectrum of different changes, which shall optimise our healthcare world to a 'digital health' environment. Many doctors optimistically start tiny DH islands using AI, robotics or, for example, digital imaging in their work. However, possible negative side effects are underestimated. In particular, new risks due to a higher vulnerability of infrastructures and fake results in naive research approaches endanger the quality and manageability of healthcare systems designed for strong and trustful professionals and citizens based on reproducible scientific efficiency evaluations. Some of the key components of this historical development are summarised in the following sections addressing risks and urgent to-dos.

The digital transformation will massively overhaul health services, research and training: a big challenge to all of us is the fact that we currently do not know the dynamics of many positive or negative effects of these winds of change. Examples include the time cycles required for changes in infrastructures or expensive equipment, the appropriate management of clinical decision support systems (CDSSs), particularly the alignment of AI module training datasets with targeted patient groups, the development of essential practical skills for health professionals, the continuous updating of knowledge to maintain clinicians' competence, and the conceptualization of new approaches to patient safety and privacy. Many positive options exist, but some changes may also have extremely negative impacts on the availability of understandable and trustworthy treatments for patients.

Differences in the speed of change may advance national disparities in healthcare: currently, countries address this wave of change very differently. The same is true for educational systems, universities, professional organisations or industries. The adaptation of legal systems and security infrastructures to emerging threats is becoming increasingly complex. A new landscape shaped by highly influential international individuals and companies appears to be a key driver of these developments. Some countries seem to be managing this transformation effectively, while others remain constrained by outdated structures and processes. In health research, several countries have spent the past 20–30 years building new infrastructures to support the collection and use of research data, including digital data platforms and biobanks for biological specimens. The experience in Germany has been particularly complex and has shown that meaningful progress requires openness to substantially reassessing existing processes and structures, although this often raises individual concerns and can slow down reform.[20]

Scientific organisations addressing a broad professional spectrum have to preserve quality: this situation is endangering scientific societies addressing the use of BMHI (eg, IMIA or regional or national organisations). Industrial companies, governments, management boards, doctors and many managers in healthcare believe that it is possible to improve their activities just by buying new information technology solutions and thus becoming part of the creative futuristic world of AI. These assumptions destabilise current healthcare systems. Instead, scientific organisations with deep know-how of the pros and cons of the current transformation enable other professionals to learn together with them how to drive the changes in a world of values, trust and legal rules. This means that scientific societies have to collaborate much more with representatives of DH, health economics, software and hardware design, etc. This will not be easy and sometimes confrontational—but it is the only option to stabilise our historically grown value-based research infrastructures and healthcare worlds during the coming decades of transformation. Historically, we are in a similar redesign of healthcare and research as in the second half of the 19th century, when the natural sciences had a similar wave effect as AI today on healthcare systems, medical research and teaching. Chances for better lives in improved healthcare systems are great. There is a need for many more professionals in all roles in the future healthcare systems, which have a deep understanding and update in BMHI than currently—a condition sine qua non!

Health science and healthcare organisations must adapt to meet the challenges: the historical speed-up of knowledge creation and growth—linked with new instruments to handle gigantic amounts of data—transforms human roles and interactions to an extent that is still not fully understood. This is true for all dimensions of life—from disastrous new military strategies to all activities aimed at building, educating, training and updating human capacities for health and fair social

living—whether for professionals or patients. The scientific organisations have to adapt their construction and internal collaboration to these massive changes. In particular, those who have been focusing on data analysis, computer-based methodologies, etc—often named 'biomedical informatics'—are facing quite a challenge: they have to become open for the growing number of professionals and restructure their organisations to adapt to the envisaged massive growth of professionals and new professions in the field. At the same time, they have to remain scientifically correct in those dynamic winds of knowledge growth. Historical differences in national healthcare systems have dominated the constructions of national scientific medical societies; however, it is very likely that these differences will disappear because of the overwhelming historical dynamics described in this text. The changes will not be easy but are necessary to survive. BMHI is one of the key scientific disciplines that empower transparent and trustful changes forward into a better future.

To conclude, one can say that despite all dynamics, learning and critical evaluations take time. The first CDSS approaches started in the 1950s (eg, ref [21]) and underwent several learning cycles (eg, ref [22]). The current AI wave has pushed a massive new DH world, which urgently needs a scientific evaluation by medical informatics scientists knowing the lessons learnt from the previous CDSS waves (eg, ref [23]). These dynamics are normal learning processes between creative biomedical informatics scientists, doctors and patients in the real healthcare world efficiently transforming their worlds into DH environments.

DISCUSSION: CONVERGENCES AND DIVERGENCES AMONG EXPERT PERSPECTIVES

The seven perspectives gathered in this article, although rooted in different national contexts, disciplinary traditions and career trajectories, converge on several essential points while revealing meaningful challenges that deserve explicit acknowledgement.

Areas of agreement

A first and overarching convergence is the unanimous rejection of the conflation between BMHI and DH. All panellists agree that these two terms are fundamentally distinct: DH represents an applied, implementation-oriented domain, while BMHI constitutes the underlying scientific discipline. BMHI generates knowledge, DH deploys it. As articulated across multiple contributions, equating the two would be a categorical mistake, one that would obscure decades of methodological and theoretical development within BMHI.

This consensus extends to the hierarchical relationship between the two fields. Whether framed through a hierarchical model (Edward Hance Shortliffe, EHS), an engineering metaphor (William Ed Hammond, WEH), a symbiosis metaphor (Heimar de Fatima Marin, HdFM) or an explicit formulation such as 'Medical Informatics, the science that drives Digital Health' (Yu-Chuan Jack Li, Y-CJL), all contributors agree that DH rests on the scientific foundations laid by BMHI. BMHI is, in the words of HdFM, "the invisible architecture that makes DH possible."

All panellists also concur that terminology matters beyond pure semantics. Words carry institutional, sociological, political, cultural and strategic weight. Naming affects funding, academic recognition, public visibility and the inclusion or exclusion of professional communities. The proliferation of terms reflects both genuine scientific evolution and external pressures from industry, policy bodies and the media, a tension made concrete by the BMJ journal naming episode recounted by Y-CJL.

Finally, there is broad agreement that the relationship between BMHI and DH should be framed as complementarity rather than competition. DH brings reach, consumer engagement and policy traction; BMHI brings scientific rigour, evaluation frameworks and long-term credibility. Both are necessary for a sustainable and trustworthy digital transformation of healthcare.

Areas of challenges

Despite these convergences, the perspectives also reveal meaningful challenges that the field must not overlook.

A first challenge concerns the degree of pragmatic accommodation towards 'Digital Health' branding. Christian Lovis (CL) has pragmatically renamed academic programmes to DH to attract new audiences and strengthen interdisciplinary governance, viewing this as an act of inclusion. By contrast, EHS firmly warns against renaming scientific programmes with an applied label, and PD cautions that constant renaming adds complexity without conceptual clarity. This tension between strategic pragmatism and principled conservatism calls for an explicit collective debate within the BMHI community.

A second challenge concerns the epistemological anchoring of the field. PD questions the classical data–information–knowledge pyramid and proposes a semiotic triangle as a more accurate model. WEH anchors the discussion in Shannon's information theory, emphasising measurement and uncertainty reduction. Others ground their arguments in translational impact, interdisciplinary practice or historical continuity. These differences shape how each contributor defines the boundaries, methods and success criteria of BMHI and suggest that the field does not yet share a single foundational epistemology.

Another challenge relates to the role of market and private sector dynamics. Y-CJL explicitly acknowledges that DH operates according to areas of emphasis that are different from academic BMHI, including business models, regulatory pathways and scalability requirements. His wireless blood pressure monitoring case study illustrates a genuine gap: a project that was an academic success was simultaneously a DH failure because it was not scalable or market ready. BMHI aims to prove that something works, whereas DH seeks to make it work at scale. Other contributors address this distinction less

directly, suggesting the scientific community has not yet reached consensus on how to engage with industry-driven dynamics while preserving scientific integrity.

A fourth challenge concerns risk awareness and the pace of transformation. Otto Rienhoff (OR) stands out for foregrounding the dangers of rapid, uncritical digital transformation: infrastructure vulnerability, AI-generated misinformation, national disparities in adoption and the erosion of trust-based healthcare systems. The extent to which BMHI communities should act as critical evaluators and safety guarantors of digital transformation, rather than simply enablers, remains an open and pressing question.

The last challenge concerns cultural and contextual variability in terminology. HdFM demonstrates that the same term carries different meanings across national and professional contexts: 'biomedical informatics' risks confusion with a regulated laboratory profession in Brazil, while 'digital health' resonates differently with policymakers in Taiwan than in Europe. These contextual differences challenge any attempt to impose a single global taxonomy and argue for culturally sensitive, locally adaptable framing strategies.

CONCLUSIONS

Taken together, these perspectives suggest that BMHI and DH should not be viewed as competing labels but as complementary dimensions of a shared endeavour, one grounded in scientific rigour and the other oriented towards implementation, visibility and societal impact. This points to five priorities for the field moving forward. First, BMHI communities need a shared, formally endorsed conceptual framework that clearly positions DH as an applied domain within the broader scientific architecture of BMHI. Such a framework, developed collaboratively through bodies such as IMIA, should guide education, research funding and policy engagement. Alignment with international reference documents, including the WHO Global Strategy on Digital Health 2020–2025[7] and the United Nations Sustainable Development Goals (SDG), notably SDG 3 on Good Health and Well-Being,[24] would strengthen its policy relevance and global reach. Second, education and training programmes should distinguish, but not sever, scientific formation in BMHI from applied training in DH. Master's programmes in DH are legitimate and valuable; what must be avoided is allowing them to substitute for or undermine the scientific depth of BMHI programmes. Third, scientific societies must proactively engage with policy, industry and public health actors rather than retreating into disciplinary defensiveness. As OR argues, this engagement will be demanding and at times confrontational, but it is the only viable strategy for ensuring that the digital transformation of health is guided by evidence, values and rigorous evaluation, particularly as AI-based CDSS are deployed at scale. Fourth, the field should prioritise the resolution of enduring technical and governance challenges that transcend any naming debate: universal patient identification, semantic interoperability, shared data models and the responsible integration of AI into clinical workflows. These problems, identified decades ago by pioneers such as Cimino[13 14] and still unresolved, represent the most concrete common ground across all perspectives in this panel. Fifth, BMHI communities should treat this terminological debate as a diagnostic signal. The confusion between BMHI and DH, evidenced by the audience poll at MEDINFO 2025, where only one-third of attendees clearly distinguished the two fields, reveals a real and consequential communication gap. Investing in public-facing, policy-oriented and cross-disciplinary articulations of BMHI's identity and value is not a concession to marketing logic; it is a scientific responsibility.

Thus, the path forward for BMHI in the DH era is neither to resist change nor to be absorbed by it, but to shape it with scientific rigour, inclusive governance and a clear-eyed awareness of both the opportunities and the risks that digital transformation brings to healthcare systems. However, if preserving the scientific foundations and identity of BMHI through informatics-based terminology is essential, while recognising the strategic value of the term DH in mobilising resources and supporting innovation, beyond terminology, institutional positioning and strategic narratives, health itself remains an overarching societal objective. The central challenge is, and must remain, the effective *care* of individuals and populations. If digital and computational tools are indispensable enablers of this mission, their true value lies in how they support health professionals in delivering better, safer, more equitable and more human-centred care.

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