Original Researcher Article

Scholarship On Biomedical and Health Informatics Education

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ABSTRACT

Biomedical and Health Informatics (BMHI) has substantial importance in the Healthcare system of any country and indicates a need to strengthen education in this field. There is a trend for development of BMHI which can be interpreted geographically. In the first half of the 20th century, the health sector started to receive some advantages from the initiation of informatics technology. Healthcare informatics pioneered in some of the west European and North American countries, alongside the International Medical Informatics Association (IMIA) as a torchbearer for education and training for this discipline. BMHI has evolved through the structured education curriculum and thereafter penetrated the developing countries as well. This paper attempts an abridged description pertaining to the geographical patterns in the development of BMHI and its education. Significance of Problem-Based Learning (PBL) and potential for professional developments have been highlighted together with the challenges in this field. Finally, situations in India have been put forward to depict the progression of BMHI education and implementation of informatics in healthcare

Keywords: Biomedical and Health Informatics, International Medical Informatics Association, medical informatics, Problem-Based Learning

INTRODUCTION

Medical or health informatics has been defined as "the field that concerns itself with the cognitive, information processing, and communication tasks of medical practice, education, and research, including the information science and the technology to support these tasks" (Moehr and Grant, 2000). The term medical informatics was coined by Francois Grémy and Peter Reichertz when it had gradually originated by the early 1970s, in France and by 1980s, in the USA. In 1988, an undergraduate course was taught in the Nursing School of the University of Athens where the terminology of medical informatics was changed to health informatics (Mantas, 2016). BMHI infrastructure, training and education programs have been addressing this area since the 1940s. Academia and industry have come together to configure curricula and competencies in BMHI. In this regard, initial endeavours could be witnessed in some of the countries of west European and North America. Organizations such as International Medical Informatics Association (IMIA) and American Medical Informatics Association (AMIA) have worked on promoting education and training for improving healthcare informatics both in developed and developing countries. This paper attempts to understand the core themes of BMHI education through a detailed peruse on the development of the discipline, professional opportunities and challenges.

1. Methods

This study adopts a qualitative, descriptive, and integrative review design to examine the evolution of BMHI education, professional development, and associated challenges across different geographical contexts. The methodological orientation is historical–analytical in nature, enabling a systematic tracing of the emergence, institutionalisation, and expansion of BMHI as a multidisciplinary field. This approach is complemented by thematic synthesis, which facilitates the identification and interpretation of recurring educational models, pedagogical practices, and professional trajectories within the literature. Such a design is appropriate for addressing the paper's objective of contextualising BMHI education within broader socio-technical and geographical frameworks rather than generating new empirical data.

1.1. Data Sources and Literature Selection

The study relies exclusively on secondary data derived from peer-reviewed journal articles, academic books, policy documents, institutional reports, and archival literature related to medical informatics, health informatics education, and health information systems.

Literature published between the 1940s and the early 2020s was considered in order to capture both the historical origins and contemporary developments of BMHI. A purposive selection strategy was employed to include sources that explicitly addressed the conceptual foundations of BMHI, educational curricula and competency frameworks, global and regional initiatives in informatics education, pedagogical approaches such as Problem-Based Learning (PBL), professional roles and workforce development, and challenges faced by developing countries, particularly India. Priority was given to authoritative and frequently cited works to ensure analytical rigour and disciplinary relevance.

1.2. Analytical Framework

The selected literature was analysed using a thematic categorisation framework, wherein texts were systematically reviewed and organised into analytically meaningful domains. These domains included BMHI education and training structures, geographical patterns of development, institutional and organisational initiatives, pedagogical innovations, professionalisation processes, and structural and ethical challenges. Comparative interpretation was employed to highlight variations between developed and developing regions, thereby enabling a geographically informed understanding of how socio-economic conditions, technological infrastructure, and policy environments shape BMHI education and practice. Conceptual frameworks and recommendations proposed by international professional bodies were used as reference points to contextualise educational standards and competency expectations within the field.

1.3. Focus on PBL

PBL was examined as a distinct pedagogical component within BMHI education through a focused review of educational theory and empirical studies. The analysis considered how PBL contributes to interdisciplinary learning, critical thinking, and applied problem-solving skills in contrast to traditional discipline-based instructional models. Emphasis was placed on synthesising evidence related to cognitive processes, knowledge integration, and learner autonomy, in order to assess the relevance of PBL for preparing BMHI professionals capable of addressing complex healthcare and informatics challenges.

1.4. Contextual Analysis: India

A contextual analysis was undertaken to examine the development of BMHI education and implementation in India. This component drew upon national policy documents, institutional developments, and published research to situate India's progress within the global BMHI landscape. The analysis focused on identifying structural gaps in education and training, emerging opportunities linked to digital health initiatives, and challenges related to workforce capacity, infrastructure, and curriculum design. This contextual examination enabled a critical assessment of how global BMHI frameworks interact with local healthcare needs and institutional realities in India.

2. Results and Discussion

The Results and Discussion section is thematically organised to synthesise evidence on BMHI education, professional development, and systemic challenges. It begins with an examination of BMHI education and training frameworks, drawing on competency-based models advanced by the International Medical Informatics Association and the American Medical Informatics Association. The discussion then traces the geographical evolution of medical informatics across Europe, North America, Asia, and developing regions. Subsequent subsections analyse the role of Problem-Based Learning, the professionalisation of BMHI, and workforce demands. The section concludes by critically situating these global patterns within the Indian context, highlighting policy initiatives, institutional capacities, and persistent challenges shaping BMHI education and practice.

2.1. BMHI education and training

IMIA envisages knowledge or skills in three domain areas which has also been used as point of reference by Johnson to propose a framework for BMHI curriculum consisting three levels of competencies, namely: formal, empirical and applied (Huang, 2007). The first categorisation of domain by IMIA is technology utilized for the processing of data, information and knowledge in medicine and healthcare. The second and third domains incorporate aspects of medicine, health, biosciences, health system organization, along with informatics or computer sciences, mathematics and biometry, respectively. IMIA was instituted in the year 1967 and Dr. Roger Salamon and Dr. Francois Grémy were one of the founding members. From the 1970s, this association has been working towards BMHI Education. IMIA proposed some recommendations (Mantas et al., 2010) to assimilate the scope of education in public health informatics in myriad disciplines. Students in a bachelor degree (three or four years) must be occupied with modules which secure knowledge in advanced health informatics study, medicine, health sciences, biosciences, problems in diagnosis and public health. At least one year for a master degree and three to four years for Ph.D., has been recommended to provide theoretical, practical and analytical skills. IMIA has projected the importance of education for health record administrators, in two levels-introductory and deeper understanding of knowledge, through developing problem solving and critical thinking. The recommendations not only indicate lifelong learning and teamwork but also appropriate education for teachers, positions for retired faculty, problem oriented teaching, multidisciplinary understanding, exchange programs, simultaneous incorporation of traditional lectures and distance learning, are presented as some of the prerequisites for BMHI education.

Another contribution in BMHI education and training has been conveyed by AMIA through its 10×10 course (Hersh and Williamson, 2007). Syllabus of the virtual mode has a syllabus for this program has a 12 point categorization, including history and overview of BMHI; public health informatics, bioinformatics and biomedical computing; decision support in organization and management issues; maintaining standards, privacy, digital libraries and electronic health records; evidence-based medicine and telemedicine; finally career and

professional development. BMHI education has also emerged in non-health science faculties for instance, Master of Business Administration in Health Informatics in University of Hull, Hong Kong, Master of Commerce in Health Informatics in University of New South Wales, Sydney and others (Huang, 2007).

2.2. A worldview for the development of medical informatics

Traversing through the timeline for the origin of BMHI, it can be interpreted that developing nations had taken a lead. The importance of this discipline was recognized in countries of Western Europe and North America, well ahead as compared to the rest of the world. At an early stage, these countries had adopted informatics together with public, private or philanthropic investments on healthcare and education. BMHI education utilized information and communication technology to impart quality medical education which proliferated the evolution of mechanisms such as telemedicine, e-health and m-health. Germany, France, USA, Canada and other developed countries had anticipated the need for informatics education and had shifted their healthcare developmental goals from curative clinical approaches to preventive ones. Medical informatics has induced these countries to envisage healthcare as a basic need and has surfaced the path for further strategies in health promotion. BMHI education has originated in methodical and practical manners for the developed countries because of their equipped infrastructure, realization of national goals or priorities for development, increased investment and opening of avenues in this field. Subsequently these countries have aided the developing world to build a robust healthcare system through enhanced informatics education in healthcare. Abridged world view pertaining to the patterned geographical development in BMHI and its education opportunities have been attempted in the following paragraphs.

Initiatives in Europe: Medical Informatics was called medical cybernetics in the Soviet Union and the first department in this discipline was established in 1961, at Leningrad. Electronic healthcare management systems originated in Denmark in 1968. Francois Grémy was the architect of the course on medical applications of computer techniques, in 1969, at Pitié-Salpêtrière, in Paris, France (Mantas, 2016). By the late 1960s, the West European nations had accomplished the establishment of informatics in several hospitals, by the drive of some innovators like Peter L Reichertz from Germany and Francois Grémy from France. In Germany, a model syllabus for informatics was developed in May 1969 and the German Informatics Society was established in the later part of the same year. In 1972, a medical informatics program was instituted in collaboration with the two Universities of Germany, where pioneers like Franz Leven, Jochen Möhr and Reinhold Haux were associated. These two Universities of Heidelberg and Applied Sciences Heilbronn, have in turn stimulated instituting other schools for medical informatics education (Knaup et al., 2003). This interdisciplinary education program runs in national cooperation and international partnership with hospitals in Heidelberg and Heilbronn, universities of Amsterdam, Minnesota, Utah, Tyrol and several research institutions. The scientifically oriented medical informatics program encompasses theoretical and practical knowledge or skills, inducing its graduates to work towards research and methodical development in this field. In joint effort with Peter Reichertz, along with the German Informatics Society and the Association for Medical Documentation, Informatics, and Statistics a structure for BMHI education was defined in 1973. The department of Medical Informatics at the Free University, in Amsterdam, Netherlands. BMHI education and training was formulated by the Medical Informatics Subcommittee, which was a part of the Committee for Medicine of the Royal Netherlands Academy of Arts and Sciences. Both the above mentioned initiatives were inaugurated under the chairmanship of Jan van Bemmel, in 1973 and 1987, respectively (Mantas, 2016). In 1979, the first Nobel Prize in physiology and medicine was awarded for medical informatics, to the laureates, Godfrey N Hounsfield, from the United Kingdom and Allan M Cormack from the United States (Masic, 2013).

Initiatives in the USA: From the 1940s, Joshua Lederberg and William S Yamamoto were the pathfinders of automatic calculation in medical informatics. The National Institute for Healthcare in the USA was established in 1960. In the same decade, Computer-assisted medical decisions had started to develop significantly, under the leadership of Homer R Warner and other collaborators (Masic, 2013). Simultaneously, Programmed Logic for Automatic Teaching Operations was adopted in the University of Illinois, which paved the path for enhanced use of informatics in healthcare and since then several academic institutions in the USA have been engaged in educational programs pertaining to medical informatics (Mantas, 2016). The United States has further flourished in BMHI after the establishment of the National Library of Medicine and here, post-doctoral education was emphasized by the guidance of pioneers in Medical informatics, like Bamett, Blois, Greenes, Levy, Myers, Shortliffe, Stead, and Warner (Zimmerman et al., 1988). In 1981, a health computing program was attempted for a PhD level in the USA, by the Association for Computing Machinery (Mantas, 2016). Bioinformatics courses are widely included in some MI and BMI programs, particularly more in the universities of the USA.

Initiatives in Canada: Parallely, the two foremost medical schools concerned with medical informatics were located in Dalhousie, in the eastern province of Nova Scotia and in Calgary in Alberta of west Canada. PBL methods together with unprecedented health information research was started in McMaster, in Ontario, Canada, so as to popularize the importance of clinical decision making and usage of evidence based methods in healthcare (Grant and Tremblay, 1998). In Canada, another significant effort on BMHI education has been evident from 1981, with the establishment of the School

of Health Information Science at the University of Victoria. Interdisciplinary approach has been adopted in consultation with several stakeholders from both industry and academia, so as to promote courses in graduate, postgraduate and doctorate levels as well as through distance learning methods (Kushniruk et al., 2006). Another landmark instance would be the founding of Canadian Institute for Health Information, in 1993, in order to maintain health related data and to create public awareness through sound health policies (Alvarez and Zelmer, 1988).

Initiatives in Asia: In Japan, by the beginning of the 1990s, electronic data for healthcare besides telemedicine systems were installed. Medical Informatics in China was initiated from the early 1960s from the medical libraries and the discipline of information science. But the foundation of an organisation dedicated to this field was witnessed in 1983, when by the Chinese Medical Informatics Association was endeavoured by Dr. Z. Ouyang. The scenario of medical informatics in other Asian countries was similar where, in 1987, the Hong Kong Society of Medical Informatics was instituted by Dr. Tan and along the same time, in 1989, the Korean Medical Informatics Society was embarked upon by Prof. C.S (Kaihara, 1999). By recognizing the importance of BMHI, countries like Singapore have implemented policies like 'One Patient, One Health Record'.

Initiatives in developing countries: In 2005, the 10x10 program of the AMIA and Oregon Health & Science University was adapted to the Latin American setting. This program was delivered in Spanish which was translated by the task force of medical informatics in the Hospital Italiano, at Buenos Aires. Among the total 152 participants, most of them belonged to healthcare professions in Argentina and 93% of the total participants had completed the course which indicates the success of its implementation (Oterao et al., 2007). The Department of Health, Eastern Cape in collaboration with the South African Medical Research Council, the Walter Sisulu University, in South Africa, and the University of Winchester and Centre for Health Informatics Research and Development, from the United Kingdom, had started an MSc Health Informatics in 2006. In June 2007, the national electronic health record strived to strengthen the condition of health informatics, BMHI education, training and capacity building in South Africa (Murray et al., 2009). The US based Informatics Training for Global Health Program has operated in alliance with local universities and institutions to fund eight such partnerships in developing countries like Africa, Latin America and India (Hersh et al., 2010). This program has recognized the significance of BMHI education and is compatible with local customs, culture and healthcare needs. The ubiquitous literature search engines, such as MEDLINE and PubMed have also increased the accessibility of BMHI research.

2.3. PBL in BMHI education

PBL in BMHI is synonymous to the concept promulgated by Paolo Freire (Freire, 2011) as it upholds self-directed study and multidisciplinary skills, in contradiction to rote learning, with the objectives of- learning to learn, learning to analyse and solving problems. The traditional evaluation methods assess competence based on parrot-fashioned learning which could be detrimental when it comes to implementing solutions to practical problems. Thus PBL has been taken up as one of the most relevant methods of acquiring and stimulating knowledge. Students are benefited by less dependence on the pedagogical skills of their teachers. According to a study by Blumberg (Hasman and Boshuizen, 2001), students under the PBL curriculum have a deeper understanding, improved autonomy and are active library users. Hence a counter approach to BMHI education- Problem Based Learning, has been implemented by several universities, engaged in medical informatics. Mayer and Greeno, 1972 have advocated the impact of different instructional methods on dedicated learning outcomes (Schmidt, 1983). The method of learning designates the ways in which a student implements a gained information or applies it towards problem solving. Anderson describes the three principles for acquiring new information (Hasman and Boshuizen, 2001) as, activation of prior knowledge, elaboration of the knowledge and encoding specificity. Tulving and Thomson, 1973 have defined the term encoding specificity as the successful retrieval of information for problem solving in practical situations through reactivating and encoding the previously acquired information (Schmidt, 1983). PBL is contributory in an environment of cooperative learning which could result in restructuring of knowledge or in conceptual change. In PBL, the existing knowledge is questioned, evaluated and alternative theories are thought upon by student group members. Hypotheses are verified during revision and self-study which promotes restructuring of knowledge (Grave et al., 1996).

In PBL, the educational program is divided into blocks and different disciplines are integrated with respect to the theme of these blocks. Small group discussions begets theory building, data exploration, meta-reasoning and stimulates thinking processes regarding the hypothesis evaluation. Such verbal interactions induce activation of prior knowledge, facilitates understanding of new concepts and elaborates on one's own knowledge. Understanding of the problem and exchange of ideas with other students lead to enriched cognitive structures among the participants. BMHI education has been witnessed in a Problem-based and applied learning system which was first introduced by the Faculty of Health Sciences, McMaster University in Hamilton, Canada, back in 1969 (Hasman, 1998). The department of Medical Informatics, under the faculties of Medicine and of Health Sciences, was established at Maastricht University, in 1985 (Hasman and Talmon, 2000). Medical informatics had been taught in the Maastricht University as a separate program or as integrated with non-medical informatics topics. Logistics of the PBL can be approached through seven stages (Hasman and Boshuizen, 2001), namely- clarifying the terminologies, defining, analysing and explaining the problem, formulating learning goals, collection of additional or external information, finally,

synthesizing and testing the newly acquired information. This seven-jump method in Maastricht University ensures a deeper understanding and firm approach towards problem solving (Grave et al., 1996). Also in Harvard Medical School Tutorial group teachers have favored problem oriented teaching and teamwork to attain better learning outcomes.

2.4. Development of profession in BMHI

Pavalko defined that a profession is characterized by a strong knowledge base, intellectual technique, relevance to basic social values, specialized training, autonomy in practice, long-term commitment to profession, sense of community and highly developed code of ethics and service ideals which are ahead of self-interest. Joyub has analyzed the HIT profession in the United Kingdom based on Pavalko's framework and determined that this field is in its novice state for developing as a profession (Hersh, 2006). In America, Gartner Research has analysed 40 integrated health delivery systems and found a staffing ratio of one IT staff per 48 non-IT staff. The BMHI workforce in England has been estimated as about one information technology staff per 52 non-IT workers and this ratio is analogous to Australia (Hersh, 2010). Healthcare and public health informaticians are encouraged to be recruited in universities, research centers, government agencies, industries and research and development sections of software companies. BMHI systems need to be strengthened through participation of physicians, IT professionals and researchers.

The approach of the medical informatics program as a joint venture of the University of Heidelberg and the University of Applied Sciences Heilbronn is acceptable for employers (Knaup et al., 2003). It is evident from the contribution of their Medical informatics graduates towards diverse occupations such as, information systems in healthcare, medical image processing, bio-signal processing, industries, self-employment, knowledge based methods, bioinformatics and other branches of medical informatics. Students from University of Victoria, Canada has been engaged in professional roles of project managers, privacy officers, health information technology policy makers, consultants, directors, chief information officers and academics (Kushniruk et al., 2006).

Some of the directions for Healthcare Informatics and Technology (HIT) in USA, as recorded by the AMIA and American Health Information Management Association (AHIMA), in a summit held in late 2005 (Hersh, 2008), are- establishing the Institute of Medicine for designating three core competencies for patient-centered care, employing evidence-based practice and applying quality improvement in BMHI education. Other suggestions included, enhancing the quality of the Healthcare system through HIT or industry based training for BMHI workforce, promoting awareness development, innovating the learning environment and strengthening formal education programs. Finally this report advocated disseminating tools and best practices for the success of BMHI professionals. In the 21st century, a new role or new profession of the informationist has been highlighted.

This position has been derived from the traditional occupation of clinical librarianship and it also incorporates a broader set of skills of medical informatics (Hersh, 2006). New skills of these professionals would be leveraged through incentive programs, for instance the American Recovery and Reinvestment Act includes investment in workforce development (Hersh, 2010). Cross-training for informaticians and translational researchers accompanied with apertures of new jobs and career paths would encourage graduates to be motivated for working in BMHI. New centers and faculty positions at universities or institutes must be created for focused application of informatics to translational research (Payne et al., 2005). For wider coverage of BMHI, mobile adoption support personnel are being deployed at different locations, for a specific period of time and they are transferred after the job is done. These individuals might be employed by regional extension centers and public health agencies for technical support, training, public health and information management (Hersh, 2010).

2.5. Challenges to BMHI education

BMHI in its initial days lacked a succinct definition, in fact debates were seen whether a practitioner should be called an informaticist or informatician (Hersh, 2008). Medical informatics is a heterogeneous field incorporating diverse disciplines, skills, and knowledge. This statement poses both a challenge and a boon towards further development in this field. Amalgamation of knowledge from multiple disciplines would prompt an initial obscurity but working at the intersection of healthcare and IT is advantageous for the recipients. There are concerns about privacy or confidentiality and lack of interoperability in this field. A mismatch of return on investment between those who pay and those who benefit from healthcare is evident. There are several discoveries in biomedical sciences but their implementation is scarce in clinical and community practice. Translation of scientific discoveries into public health practice has served as a potential challenge (Payne et al., 2005). Another problem lies with the doctors who are more resistant to the introduction of informatics in healthcare.

Traditionally BMHI education has been ventured through a discipline-based method (Hasman and Boshuizen, 2001), where students (as passive recipients) are implicitly stimulated to acquire factual knowledge. There had been a dependence on the pedagogical skills of the lecturer, which had been diminished to a greater extent by the introduction of PBL. Even after the adoption of PBL, the education system in BMHI has equivocal study modules across the world. It is difficult to comprehend upon the syllabus, names, design and content of the courses. For instance training in US, UK, and Canada tends to focus at the graduate level whereas there are many baccalaureate programs in Germany, which include informatics in healthcare education. Also many countries are now adopting distance learning programs in BMHI education and there is a lack of consensus on the competencies and curriculum in this field. Subsequent challenges in BMHI education and profession are, lack of standards, training or skills and deficiencies in knowledge

among workers. There is an ambiguity regarding the required academic degree to educate students enrolled in BMHI or to train HIT workforce. The necessary competencies for teaching or recruitment in other employment opportunities are not only well developed but are also diverse. In the USA, Standard Occupational Classification codes have been separately denoted for health diagnosing or treating practitioners and for health information technicians. But there is no code for any all-encompassing position on BMHI, nothing combines the myriad heterogeneous clinical and other informaticians into a single code (Hersh 2010). Research opportunities in BMHI are liable to worldwide divide between the developed and the developing nations. In 2002, the then Editor of British Medical Journal, Richard Smith had commented that only 10 percent of all health related research is conducted in the developing world. As a trajectory towards solution, a new Open Access journal called The Journal of Health Informatics in Developing Countries was established in early 2007.

2.6. Development of medical informatics and BMHI education in India

India has efficiently progressed in IT profession, productivity and education, but it is not yet in pace with the world dynamics of BMHI. The need for implementation of BMHI in India could be exemplified in the sub-Himalayan region, where local inhabitants are much more prone to goitre, because of insufficient iodine in the soil and water over there and due to high amounts of cabbage consumption by the residents. It can be analysed that local dietary and other environmental factors makes the people vulnerable to a specific disease pattern. This situation can be epidemiologically handled only through the coherent use of medical informatics (Sarbadhikari, 2005). Trained employees in BMHI are of utmost necessity pertaining to the fact that healthcare is increasingly being corporatized additionally, demand for telemedicine has also accelerated (Sarbadhikari and Gogia, 2010). Therefore requirements for attaining sufficient competencies in this field can only be met by bracing the education and training opportunities for the concerned people. To keep up with the fast changing healthcare systems, it is essential to build up relevant curricula to develop professionals in this field. BMHI Education in India, must have a flexible rather than rigid syllabus, in order to accommodate all members of the healthcare delivery system. BMHI education must be applied to various universities, institutions and for training the workforce for optimal delivery of their services.

Medical Informatics has been gaining popularity in undergraduate (MBBS, BDS, BPharm, BSc in Nursing) and postgraduate courses (MD, MDS, MPharm, MSc in Nursing). The Medical Council of India had proposed offering subjects including, informatics, genomics and ethical aspects of biomedical research as audit courses in the beginning of the MBBS. For education in health related fields in India, PBL has been intended with greater significance that has been reaffirmed through computer aided learning which provides remedial information and navigates students through a course (Sarbadhikari, 2005).

School of Medical Science and Technology was established in 2001, by Indian Institute of Technology so as to commence a postgraduate program only for medical graduates. Individual institutions or centres dedicated to research in artificial intelligence, biomedical, electrical and communication engineering have been proliferating since then. Although some public and private centers are also involved in promoting short-term courses in medical informatics for doctors' training, such modules are not adequate because they need to be modified in accordance with the schedules of the professionals and the needs of the beneficiaries. Some of the major organizations dealing with BMHI in India are: The Indian Association for Medical Informatics, founded in 1993, the Medical Computer Society of India; National Institute of Medical Informatics, and others.

A significant majority of public hospitals in India are yet to be digitized. On the other hand, hospitals in private sectors do not usually view public health as a thrust area. To pursue this and a series of other healthcare challenges in India, 2010-2020 was declared as the decade of innovations. This led to a proposal for developing a health information network and unique identification for public health under the supervision of the Unique Identification Authority of India. Digitization of the healthcare sector in India, has attained speed through National Health Policy, 2017, under which the National Digital Health Mission has also been launched in September 2021. This Mission has the following components: Health ID, Patient Health Record, Electronic medical record web application, Digi Doctor Platform and Health Facility Registry. Further in the rural areas, the *panchayati* raj institutions, Accredited Social Health Activists and *anganwadi* workers will augment their efforts to enable citizens with digital technologies.

Conclusion

Challenges towards developing a robust health informatics system, also include biases in distribution of funds, lacuna in health legislation, prejudiced political motives, poverty, illiteracy, ignorance, digital and technological divide, discrimination based on gender, race, ethnicity and others, which are to be overcome by institutional support. Several social problems are both the cause and consequence of lack in healthcare and these can be attempted to solve through medical informatics. Healthcare delivery personnel are to be made aware of their responsibilities towards and updated with modern BMHI training and skills. Currently, health surveillance has triggered dramatic transformation for applying informatics in public health. Several scholars have advocated the adoption of a middle range theory which would integrate theoretical along with empirical health informatics education and research. (Haux et al., 2017). Reinforcement of the theoretical underpinning in BMHI education and public health research would be achievable only through removal of methodological barriers, also an inclination towards interdisciplinary approach is inevitable. 'Inclusion of all' and 'Penetration to all' can become the two pillars for overcoming the differences in the development of BMHI.

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