and agency. At its core, biological citizenship poses the question of how people should balance the necessity of having to rely on the technical expertise of others to lead their lives, against the possibility of exerting a hitherto unprecedented level of autonomous biological agency made possible by the biotechnological changes of the last few decades. On the one hand, the complexity of knowledge and technology—biological, medical, and otherwise—with which people interface daily requires a reliance on specialized expertise; on the other hand, these same complexities make available to everyone new ways of learning about and controlling biological characteristics and their impact on people's future.

The relative newness of the biotechnologies most closely linked to biological citizenship, coupled with their pace of growth and development and the lack of established social norms and legislative regulations governing them, make biological citizenship an important concept to understand, inquire, and use. Concepts related to biological citizenship—Philip Frankenfeld, for example, proposed a model for "technological citizenship," which defines belonging to a group based on boundaries created by the usage of certain specific technologies, or of technology generally—provide additional perspectives on the kinds of questions, problems, and situations related to biological citizenship.

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See Also: Genetically Modified Organisms, Media Coverage of; Genetics; Risk Society; Scientific Complexity, Communication of.

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Biomedical and Health Informatics

Biomedical and health informatics (BMHI) is the field that is concerned with the acquisition of data, information, and knowledge to improve health, health care, public health, and research. BMHI is playing a growing role in health-related fields. On the clinical side, it is increasingly recognized for developing methods and tools to improve the quality and safety while reducing the cost of health care. For patients and consumers, it is seen as providing empowerment to use data and information to improve health. BMHI also makes contributions to research, especially in areas such as genomics, in which basic biological findings are translated to improved diagnosis and treatment of disease.

Basic Terminology of the Field

Before exploring the details of BMHI, the word *informatics* needs to be defined. This word has been around for several decades and its usage is not limited to biomedical and health disciplines. But certainly in the United States, the most prominent usage of it comes from the biomedical and health disciplines. William Hersh has defined informatics as the field concerned with optimal use of information, often aided by the use of technology, to improve individual health, health care, public health, and biomedical research.

Informatics is more about information than technology, with the latter being a tool, albeit an important one, to enable better use of information. The former School of Informatics at the State University of New York at Buffalo defined informatics as the Venn diagram showing the intersection of people, information, and technology. C. P. Friedman has defined a "fundamental theorem" of informatics, which states that informatics is more about using technology to help people do cognitive tasks better than about building systems to mimic or replace human expertise. He has also defined informatics as "cross-training," bridging an application domain (such as public health or medicine) with basic information sciences. Friedman has also defined informatics by what it is not, including analyzing large data sets, employment in circumscribed information

technology (IT) roles, or anything done using a computer.

Within BMHI are myriad subdisciplines, all of which apply the same fundamental science and methods, but are focused on particular subject domains. Edward H. Shortliffe has proposed that informatics proceeds along a continuum from the cellular and molecular (bioinformatics) to the person (medical or clinical informatics) to the population (public health informatics). The application of informatics is focused on specific health care disciplines such as nursing (nursing informatics), dentistry (dental informatics), and pathology (pathology informatics), as well as among consumers and patients (consumer health informatics) (see Figure 1). There are also disciplines in informatics that apply across the cell-person-population spectrum, as follows:

- Imaging informatics: informatics with a focus on imaging, including the use of picture archiving and communication systems (PACS) to store and retrieve images in health care settings.
- Research informatics: the use of informatics to facilitate biomedical and health research, including a focus on clinical and translational research that aims to accelerate research findings into health care.

Related Terminology of Informatics

There are a number of other terms that are important for one to understand in the context of BMHI. The term *health information management* (HIM) is the discipline that has historically focused on the management of medical records. As medical records have become electronic, this field has been in transition and increasingly overlaps with informatics. One major difference between HIM and informatics is the educational path of practitioners. HIM professionals have historically been educated at the associate or baccalaureate level, whereas informaticians often come from clinical backgrounds, including those with doctoral degrees such as M.D. or Pharm.D.

Information technology (IT) is the term generally used to describe computers and related technologies in operational settings. The academic discipline that underlies IT is computer science, which is often housed academically in engineering schools. However, IT professionals come from other backgrounds, including fields such as management information systems (MIS), whose programs are usually in business schools. Within IT and computer science are a heterogeneous array of people with varying skills, including developers, programmers, software engineers, information architects, and support personnel.

Another source of diverse terminology concerns the health record of the individual. When these records were first computerized, the term *electronic medical record* (EMR) was most commonly used. However, this has mostly been supplanted by the term *electronic health record* (EHR), which implies a broader and more longitudinal collection of information about the patient. There is increasing interest in the personal health record (PHR), which usually refers to the patient-controlled aspect of the health record, which may or may not be tethered to one or more EHRs from health care delivery organizations.

There has been a major investment in EHRs in the United States since 2009, when the Health Information Technology for Clinical and Economic Health (HITECH) Act was included as part of the American Recovery and Reinvestment Act (ARRA, also known as the economic

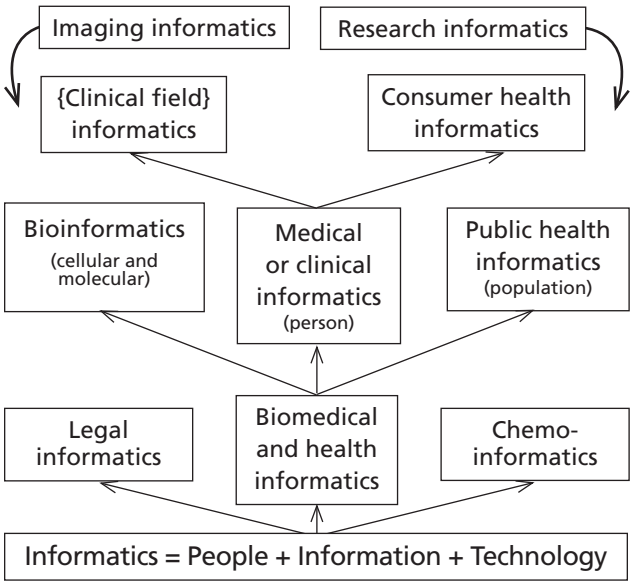

Figure 1 An overview of biomedical and health informatics and its subdisciplines

stimulus bill). HITECH allocates up to $29 billion in incentives for the adoption of EHRs by physicians and other professionals as well as hospitals in the United States. The HITECH program is administered by the Office of National Coordinator for Health Information Technology, an agency within the U.S. Department of Health and Human Services.

Related to EHR growth is interest in health information exchange (HIE), which is the exchange of health information for patient care across traditional business boundaries in health care and was also funded through the HITECH Act. Even many health care organizations that have exemplary health IT systems have difficulty providing their patient information to other entities where the patient may receive care. An increasingly mobile population also needs to have "data following the patient." HIE is actually but one example of what is sometimes called secondary use or re-use of clinical data, where data from clinical settings is used for other applications such as quality assurance, clinical research, and public health.

Another broad set of terms important to BMHI are the "tele-" terms. The two most widely used terms are "telemedicine," which refers to the delivery of health care when the participants are separated by time or distance, and "telehealth," which has more of a focus on direct interaction with health on information and communication technology (ICT). As with informatics, the "tele-" terms sometimes reflect medical specialties in which they are applied, for example, teleradiology and telepathology.

A somewhat related term is *e-Health*, which is sometimes defined as the application of ICT to health and health care. A variant of this term is *m-Health*, which focuses on applications of ICT using mobile devices connected wirelessly to networks such as smartphones and tablets.

Another area important to BMHI is evidence-based medicine (EBM). Some use the term

A doctor scrutinizes digitized medical images on his computer. Images are an essential chapter in a patient's health history, and health care professionals rely on them to diagnose or monitor illnesses and plan a patient's care. For patients and consumers, biomedics—the use of data and information to improve health—is viewed as a means of providing empowerment.

evidence-based practice (EBP), which advocates that health care decisions be made using the best available scientific evidence by those who receive care, informed by the knowledge of those who provide care, and within the context of available resources for that care. A new term to emerge related to EBM is "comparative effectiveness research" (CER), which has been defined as research studies that compare one or more diagnostic or treatment options to evaluate effectiveness, safety or outcomes.

The Value of Informatics

All of these nuanced definitions of informatics and its subdisciplines would be moot if informatics did not provide value to health. A great deal of research does show that informatics when properly applied can contribute to the "triple aim" of improved health, improved health care, and reduced health care costs. Most studies of the value of informatics have come from the health care setting, making a challenge to public health informatics (PHI) and other subdisciplines to demonstrate value scientifically in their settings. A good deal of the evidence for the value of BMHI is summarized in three successive systematic reviews.

The first systematic review to critically analyze all informatics evaluation studies to date was published in 2006. A total of 257 studies met the inclusion criteria. Most studies addressed decision support systems or EHRs. One concern was that approximately 25 percent of the studies were from four academic institutions that had implemented internally developed systems; only nine studies evaluated multifunctional, commercially developed systems. The review concluded that evidence for the value of BMHI was demonstrated most prominently in three areas: increased adherence to guideline-based care, enhanced surveillance and monitoring, and decreased medication errors. The primary clinical domain of these improvements was preventive health. The major efficiency benefit shown in the studies was decreased utilization of care. Data on another efficiency measure, time utilization, were mixed, while empirical cost data were limited.

A second systematic review was published in 2009. In this review, 179 studies met the inclusion criteria. This review found benefits from EHRs and health IT systems designed to run independently from EHRs, but little formal evaluation of other types of applications. There were somewhat fewer relevant studies from the health IT leader organizations.

These reviews were updated using the same methodology in 2011. The authors reviewed the literature similar to the previous reviews and found that 92 percent of the recent articles on health IT reached conclusions that were positive overall. The authors also found that the benefits of health IT were beginning to emerge in smaller practices and organizations, as well as in large organizations that had been early adopters. However, they also noted that dissatisfaction with EHRs among some providers was still high and a barrier to achieving value. They concluded that studies documenting the challenging aspects of implementing health IT and how those challenges might be addressed were critically needed.

Conclusion

It is critical that an understanding of PHI include the perspective of the larger BMHI as well as where subdisciplines such as PHI fit in. The value of BMHI has been demonstrated in studies and summarized in systematic reviews as well as developed via educational programs.

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See Also: Digital Personal Health Records; Evidence: Role in Campaigns; Health Information Channels; Medical Records, Electronic; Oral Health and Dentistry; Secondary Data Analysis; Severe Acute Respiratory Syndrome; Telemedicine.

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Biopower and Biopolitics

Biopower is a concept originated by French philosopher Michel Foucault and adapted by scholars in health communication and the rhetoric of health (among others) to analyze and critique the power relations involved in health-related discourses and practices. The relational nature of biopower—that it comes out of and works through sociocultural, political, economic, interpersonal, and other relationships—is especially important. Foucault developed the concept from studying how new forms of knowledge, institutions, and techniques, including those involved in clinical medicine and public health, emerged in the 18th century to regulate people's health and lives.

Like the studies from which it was derived, biopower is always historically specific; as health care systems, institutions, and practices change, so do the ways they operate and function to shape people, their actions, and knowledge about them. One might observe, for example, how health knowledge and management systems have become increasingly privatized and market driven, generating new forms of health regulation around personal health care management, evidence-based medicine, and other strategies. Health care systems and practices respond to changing values, economies, and illness patterns. Take, for instance, emergent policies, educational efforts, and drug markets generated by emergent forms of knowledge about depression, attention deficit hyperactivity disorder (ADHD, diabetes, and obesity. As suggested by anthropologist Paul Rabinow and sociologist Nikolas Rose, genomic medicine might enable new tests, therapies, values, other mechanisms around the commercial-medical mapping and engineering of life and health.

In line with Foucault's theorizing of power more generally, biopower differs from some more traditional notions of power in the following ways:

- It is not wholly or necessarily oppressive, negative, or harmful, but can impact people in various ways (therefore it must be judged based on its effects).
- It is not repressive but productive, creating various strategies, procedures, and techniques for managing people (as individuals, groups, populations) and knowledge about them.
- It produces and is, in turn, shaped by specific forms of knowledge (e.g., from clinical medicine, public health, medical research, health marketing, personal health care management) about life and health.
- It is not centralized in sites or authorities but dispersed over a wide range of health-related practices and discourses, including the small, everyday ones of ordinary people.
- Although it is driven by specific values and goals, it is not fixed but dynamic and therefore able to be adapted or revised.

Regarding the last two items, biopower works not in a top-down direction on people but by enlisting them, often through communication, to participate in their self-management. Thus, people are not the passive objects of biopower, but are shaped by and participate in its processes, though they can be variously constrained or even oppressed in their actions. People's responses have the potential to reshape the mechanisms and effects of power relationships, but they are also