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Future Directions and Future Research in Health Informatics

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Health informatics can be described as an interprofessional discipline that is grounded in the present while planning for the future.

OBJECTIVES

At the completion of this chapter, the reader will be prepared to:

1. Explore major trends and their implications for future developments in healthcare, health informatics, and informatics research.
2. Analyze techniques and challenges of planning for future directions and trends.
3. Apply futurology methodologies in identifying trends and possible, probable, and preferred futures.
4. Describe the fields of nanomaterials and nanoinformatics, the role of these fields in healthcare, and implications for the future.
5. Analyze the advantages and disadvantages of nanotechnology in health and health informatics.

KEY TERMS

backcasting, 617
cytotoxicity, 625
data visualization, 623
extrapolation, 616
futures research, 613
nanofabrication, 624
nanoinformatics, 625
nanomaterials, 624
nanomedicine, 625
nanotechnology, 624
trend analysis, 616

ABSTRACT ❖

This chapter expands on the future directions sections included in the individual chapters and provides broad guidance about the future of health informatics. First, healthcare trends in society are outlined. Second, futures studies or futurology (methods to analyze probable future directions in any field) is discussed. Third, an overview of future directions in healthcare and informatics is given: (1) person-centered health, the fusion of health information technology (health IT) into healthcare and concomitant implications for health informatics; (2) technical trends in health IT, such as the internet of things (IoT) and cybersecurity issues; and (3) clinical informatics trends, including analytics, data visualization, and improving the user experience (UX). Last, this chapter offers a section on nanotechnology and nanoinformatics. The last topics are discussed in more detail because of their likely profound impacts on society, healthcare, and health informatics in the future.

INTRODUCTION

Health informatics can be described as an interprofessional discipline grounded in the present while planning for the future. Health professionals and informatics specialists are implementing today's health information technology (health IT), while creating the foundation for the technology of tomorrow. By reviewing current trends and predictions, as well as employing tools for predicting and managing the future, health professionals and informatics specialists can prepare for their leadership roles in planning effective and innovative future healthcare information systems.

Clearly, health IT and informatics will play integral roles in the future of all aspects of healthcare. Precisely which informatics trends will prevail is not completely clear; however, emerging areas can be seen. In each of the chapters in this book, authors outlined evolving areas of influence. This final chapter offers material on healthcare trends in society, methods for

*Acknowledgment: David E. Jones's contribution was supported by Grant Number T15LM007124 from the National Library of Medicine.

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predicting the future, directions in health informatics and, finally, a section on nanomaterials and nanoinformatics.

To understand the future of health informatics, healthcare providers and informaticians need to be aware of societal trends. Examples of trends in society include the following:

- *Healthcare costs.* Analysts initially predicted continual increases in healthcare costs at about 6% annually through 2020.[1,2] Although costs are predicted to still rise over time, current spending projections are now $2.5 trillion less due to the Affordable Care Act in the United States and the economic recession that occurred in the late 2000s.[3]
- *Aging populations.* From 2000 to 2050, the global population of those aged 60 years or older will rise from 600 million to more than 2 billion.[4]
- *Increasing numbers of patients with chronic diseases.* By 2030, chronic diseases will be the leading cause of deaths worldwide.[5] The rate for diabetes alone across the globe is predicted to increase from 382 million in 2013 to 592 million by 2035.[6]
- *Predicted shortage of healthcare providers.* By 2025, the United States will have a shortage of nurses in 16 states[7] and a national shortage of 46,000 to 90,000 physicians, mostly in primary care and surgical specialties.[8]

These trends clearly have implications for the future practice of health informatics. But how does one determine and plan for these implications? Futures research, or futurology, the method used to determine future directions and trends in any field, can help answer this question.

FUTURES RESEARCH (FUTUROLOGY)

This section introduces readers to levels of change that can be anticipated in future trends. By analyzing methodologies and tools for predicting, planning for, and managing the future, health professionals and informatics specialists are able to prepare for the leadership roles they will play in planning future healthcare information systems. With a better understanding of the potential future, healthcare providers and informatics professionals can make better decisions today.

Defining Futures Research (Futurology)

Futures research is the rational and systematic study of the future, with the goal of identifying possible, probable, and preferable futures. The focus can be anywhere from 5 to 50 years in the future. The formal study of the future goes by a number of names, including *foresight and futures studies, strategic foresight, prospective studies, prognostic studies,* and *futurology*. Using a research approach to study the future formally began after World War II. Initially this field of study aroused skepticism. Since that time, a number of institutes, foundations, and professional associations have been established supporting the field of futures studies. Examples of these are included in Box 36.1. In addition, a number of educational programs related to futures studies now use the various futurology terms to describe their programs. Box 36.2 includes examples of university programs in futures studies. Researchers and corporate strategists are also using numerous concepts, theories, principles, and methods based on the field

BOX 36.1 Futures Studies: Selected Associations, Institutes, and Foundations

- Acceleration Studies Foundation, http://accelerating.org/index.html
- Copenhagen Institute for Future Studies, http://cifs.dk/about-us/
- Foresight Canada, http://www.foresightcanada.ca
- Fullerton and Cypress Colleges, and School of Continuing Education: Center for the Future, http://fcfutures.fullcoll.edu
- The Arlington Institute, http://www.arlingtoninstitute.org
- Association of Professional Futurists, http://www.profuturists.org
- The Institute for Alternative Futures (IAF) http://www.altfutures.org/home
- The Club of Rome, http://www.clubofrome.org
- *The Futurist*, http://www.wfs.org/futurist/about-futurist
- Institute for the Future, http://www.iftf.org/home
- The Millennium Project, http://www.millennium-project.org
- World Future Society, http://www.wfs.org/node/920
- World Futures Studies Federation (WFSF), http://www.wfsf.org

IAF, Institute for Alternative Futures; *WFSF*, World Futures Studies Federation.

BOX 36.2 Selected University Programs in Futures Studies

- University of Southern California (USC) Annenberg Center for the Digital Future http://www.digitalcenter.org
- Regent University: School of Business and Leadership, http://www.regent.edu/acad/global/degree_programs/masters/strategic_foresight/home.cfm
- TamKang University: Graduate Institute of Futures Studies, http://future.tku.edu.tw/en/
- University of Advanced Technology, http://majors.uat.edu/Emerging-Tech
- University of Hawaii: Hawaii Research Center for Futures Studies, http://www.futures.hawaii.edu/academic-offerings.html
- University of Houston: College of Technology, http://www.houstonfutures.org/program.html
- University of Stellenbosch: Institute for Futures Research, http://www.ifr.sun.ac.za/Pages/Welcome.aspx
- University of Turku: Finland Futures Research Centre (FFRC), http://www.utu.fi/en/units/ffrc/Pages/home.aspx/

FFRC, Finland Futures Research Centre; *USC*, University of Southern California.

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of futures research. Despite the initial skepticism today, the futures studies techniques are accepted, educational programs are available, and these methods can be very useful for healthcare providers and informaticians.

Health and informatics professionals can use traditional forecasting and planning methods in combination with futures studies methods. Strategic planning in health informatics typically focuses on projects 1 to 3 years in the future. Institutional long-range planning tends to focus on 5 to 10 years in the future. Vendor contracts for major healthcare informatics systems often cover a 10-year period, spanning both strategic and long-range planning.

There are some differences between forecasting and futures studies. First, forecasters focus on incremental changes from existing trends, while futurists focus on systemic, transformational change. Second, futurists do not offer a single prediction. Rather, they describe alternative, possible, and preferable futures, keeping in mind that the future will be created, in most part, by decisions made today. The technical, political, and sociocultural infrastructure being built today will have a major impact on the choices of tomorrow. Both traditional forecasting and futures studies methods are key to planning health informatics projects.[9] Understanding the impact of future trends and using this information for planning begins by understanding the degree and scope of change that occurs over time.

Future Directions and Scope of Change

Degrees or the scope of change can be divided into three levels.[10] First-level change does not really change the process being used or the goal one might want to achieve. This level of change makes the process in use more effective and efficient. Replacing a typewriter with a word processor is an example of a first-level change. The user is still producing a document, but the technology makes the process more effective and efficient. Within the levels of change, first-level change is the least disruptive and the most comfortable. In many ways, requests that new technology be designed to fit the workflow of healthcare providers is, in reality, a request, or perhaps a demand, for first-level change only. In fact, if the equipment and related procedures do not support the current roles and responsibilities of the healthcare providers, they quickly develop workarounds to meet their requirement that the degree of change be limited to a first-level change.

A second-level change involves changing how a specific outcome is achieved. For example, historically the peer review process used by professional journals involved sending a submitted manuscript to a limited number of selected experts for anonymous opinions. The goal was to ensure that only the highest quality articles were published. The process of review and revision could take several weeks or months. In addition, with a limited number of experts screening what was published, some degree of professional censorship existed. Articles representing a paradigm shift in thinking risked being rejected by this limited set of reviewers. Today, professional online journals and journals that prepublished online versions of an article usually offer all readers the opportunity to comment. Opening up the opportunity for all readers comment is now changing who is ultimately involved in peer review and how the peer review process is completed.

Another example of second-level change is demonstrated by patient groups within social media applications. These are changing what and how patients learn about their health problems. Groups of patients help each other read and interpret the latest research to create a new level of health literacy within these groups. Social media interactions not only change the process for achieving an outcome, but also change the relationships between the participants. As patients become organized and knowledgeable, they take a more active role in their own care and move from the role of patients needing education about their diseases into more of a collegial role, even sharing new and innovative findings with healthcare providers.

The scope of change at this level creates both excitement and anxiety within professional groups and among individual healthcare providers. The scope of practice, policies, procedures, and established professional customs, such as professional boundaries, are challenged, and resistance to this challenge can be expected. For example, in healthcare, the goals of improved health for individuals, families, groups, and communities have not changed, but technology is changing the roles and responsibilities related to how these goals might be achieved.

A third-level change alters the process and can also refocus the goal. For example, a hyperlinked multimedia journal, with a process for adding reader comments and linking to related publications, may change not only the definition of an expert but also the historical gold standard for review of new information and knowledge.

Another example is the use of knowledge discovery and data mining in the research process. In the traditional approach to scientific research, the researcher begins with a theory and a theoretically based hypothesis. This foundation is used to determine what variables or data are collected and how those data are analyzed. With knowledge discovery and data mining, the goal is to discover clusters and relationships among existing data with no preconceived concept of theories, data collection, or how these data are related, redefining (or at least expanding) the concept of the research process.

Third-level change involves changes at the societal and institutional level, typically occurring over long periods of time. For instance, the evolving role of the nurse from a handmaiden for the physician to a leader in healthcare delivery can be seen as a third-level change. Both the goal of nursing, from an efficient and effective handmaiden to a leader, is changing, as well as the activities that make up the nursing process.

Today, innovations in healthcare and computer technology are interactively creating first-, second-, and third-level changes, creating the future of healthcare within a society that is also undergoing change in most other society based institutions. Informatics experts are among the key leaders managing and guiding these change processes within healthcare. However, they face a number of challenges in achieving these goals.

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The Challenge of Anticipating Future Directions

Almost 50 years ago in 1970, Toffler published the book *Future Shock*.[11] One of the themes in the book was "what happens to people when they are overwhelmed by change. It is about how we adapt or fail to adapt to the future."[11, p. 1] Interestingly, *Future Shock* was written long before the widespread use of personal computers or the internet. As Toffler identified many decades ago in a slower-paced world, the degree and speed of change was overwhelming for many. Today, this includes both providers and consumers of healthcare who are in the midst of exponential knowledge growth and must adapt to the overwhelming changes in healthcare.

While there are no research methods for predicting the future with absolute certainty, techniques can be used to rationally predict future directions and trends. A historical example of this is the publication of the book *Megatrends* by Naisbitt,[12] well before the general population was aware of the internet or the potential of owning a computer. Megatrends are trends that affect all aspects of society. The 10 trends identified by Naisbitt are listed in Box 36.3. These trends, identified many years ago, continue to have a major influence on health informatics today.

While health providers and health informatics specialists clearly recognize the importance of planning and the long-term implications of building today's healthcare information systems, immediate challenges exist in thinking about the future. First, present issues are often more pressing and take a higher priority over tasks that can wait for another day. This type of thinking is sometimes referred to as "putting out fires." For example, a health informatics specialist may spend an afternoon answering users' questions, but as the number of communications increases, the notes documenting these calls can become increasingly sparse. Trends and patterns that could be used as a basis for a new education and training program, or for upgrading functions in the current healthcare informatics system, can be lost in the pressing demands of the moment.

Second, small rates of growth often seem insignificant. However, major trends start from small, persistent rates of growth. This is especially true when dealing with exponential growth. A few years ago, very few patients asked for copies of their health reports, and a very small percentage of t[he] patients would have considered accessing their healthcare data via the internet. As of October 2015, the Office of the National Coordinator (ONC) reported that over 90% of hospitals provide patients the option of viewing their health data online. See Table 36.1 for additional details about how hospitals and providers are engaging patients in their own healthcare via the internet and personal health records (PHRs).

Third, there are intellectual, imaginative, and emotional limits to the amount of change that individuals and organizations can anticipate. The imagined future is built on assumptions developed in the past and therefore includes gaps and misinterpretations. Future predictions can seem vague, and the further one looks into the future, the more disconnects exist between the present and the significance of the future. For example, nurses educated in small diploma schools in the 1950s and 1960s usually called a physician to restart an intravenous (IV). If nurses from that era were asked to predict the future of nursing, they would have struggled to anticipate the high levels of responsibility common in today's staff nurse role, where starting an IV is a common task.

BOX 36.3 Naisbitt's Megatrends for the 1980s

- Industrial society → Information society
- Forced technology → High tech/High touch
- National economy → World economy
- Short term → Long term
- Centralized → Decentralized
- Institutional help → Self-help
- Representative democracy → Participatory democracy
- Hierarchies → Networking
- North → South
- Either/Or → Multiple options

TABLE 36.1 Extent of Patient Engagement Functions in Hospitals

Online Patient Engagement Functionality	PERCENT OF HOSPITALS WITH CAPABILITY 2012	2013	2014	2015
Online Capabilities Incentivized by Federal Policy				
View information from health/medical record	24	39.8	90.8	95.1
Download information from health/medical record	14.3	27.8	82.2	86.8
Transmit care/referral summaries to a third party	N/A*	11.6	66.4	71.5
View, download, and transmit health information	N/A*	10	64	68.8
Secure messaging with health care provider†	N/A*	N/A*	51.3	63
Online Capabilities Not Incentivized by Federal Policy				
Request to update health/medical record	30.9	32.8	72.4	77.1
Pay bills	49.3	55.4	66.9	74.1
Schedule appointments	21.6	29.8	41.4	43.6
Request prescription refills	19.3	27	39.4	42.1
Submit patient-generated data	7.3	12.5	32.5	37.1

From Office of the National Coordinator for Health Information Technology. U.S. *hospital adoption of patient engagement functionalities: Health IT Quick-Stat #24*. dashboard.healthit.gov/quickstats/pages/FIG-Hospital-Adoption-of-Patient-Engagement-Functionalities.php; September 2016.

*Measure was not collected in survey year.

†Secure messaging was added to survey in 2014.

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Approaches for Predicting

Qualitative and quantitative methods are used in traditional forecasting and planning as well as by futurists to foresee, manage, and create the future. The use of established research methods separates these researchers from soothsayers. Multiple methods used in concert are needed to identify and address future challenges. Selected examples of methods used in conduction futures research are presented here. In addition, Box 36.4 includes resources for exploring a number of other methodologies used in this field of study.

Trend Analysis and Extrapolation

Trend analysis involves looking at historical data to identify trends over time. For example, a log of help desk calls demonstrates that over the past 2 months, there has been an increasing number of calls from clinical managers and department heads concerning the institution's newly introduced budget software. This new software offers a number of options and levels of analysis that are more robust and complex than the software that was used in the past. Initially several calls occurred from three managers who work in the same division. However, these managers are now making very few calls. Instead, the majority of the calls are coming from a different division. Extrapolation consists of extending these historical data into the future. For example, if the trend line is sloping upward, one would continue this line at the same degree of slope into future time periods. Needless to say, this historical upward trend line will not continue forever. Eventually the growth will start to slow and an S curve will develop. With an S curve, the growth is initially slow but then becomes very rapid. Once the event begins to reach its natural limit, the rate of growth slows again, creating an S-shaped curve.

A potential example of this pattern is the future use of PHRs by the general public. Initially only a small number of people were using this resource. Google, an early entrant in PHR development, withdrew from this market because of lack of interest by the general public. However, the current Blue B[illegible] ton data from the Veterans Health Administration (VHA) suggests that the use of PHRs may be at the beginning of an S curve, with the possibility of very rapid growth in the next few years. The expected patterns of growth can be used to plan educational programming as well as support services. The need for these services can be expected to grow and then level off.

While trend analysis and extrapolation demonstrate using numerical data or quantitative methods to foresee the future, qualitative methods are also important. One example of qualitative methods is content analysis.

BOX 36.4 Futures Studies Methodologies Resources

- The Institute for Ethics and Emerging Technologies, http://ieet.org/index.php/IEET/more/brin20150909
- Methods and Approaches of Futures Studies, http://crab.rutgers.edu/~goertzel/futuristmethods.htm
- World Future Society:
- Methods, http://www.wfs.org/methods
- Methodologies Forum, http://www.wfs.org/method.htm
- Futures Research Methodology Version 3.0, http://www.millennium-project.org/millennium/FRM-V3.html
- Five Views of the Future: A Strategic Analysis Framework, http://www.tfi.com/pubs/w/pdf/5views_wp.pdf
- Methodologies for Studying Change and the Future, http://www.csudh.edu/global_options/IntroFS.HTML#FSMethodols
- The Millennium Project Presentations and Speeches, http://www.millennium-project.org/millennium/presentations.html

Content Analysis

Content analysis was the major research approach used to identify the trends in the book *Megatrends.*[12] Content analysis within the futures research realm involves reviewing a number of information resources and noting what topics are discussed, what is being said about these topics, and what topics are not discussed. A current example of this type of analysis can be seen in the website created as an informational tool for public health. This application searches open-source Twitter data for health topics and delivers an analysis of that data for both a specified geographic area and the national level, thereby serving as an indicator of potential health issues emerging in the population, building a baseline of trend data, and engaging the public on trending health topics. A screenshot showing the types of data being tracked is provided in Fig. 36.1. The assumptions made in identifying resources, topics, and trends to monitor can have a major impact on determining the forecasts produced. This is one of the reasons it is important that informatics specialists review several different resources from several different perspectives in analyzing trends.

Scenarios

Scenarios involve asking individuals to envision possible futures within a certain context. For example, people may be asked to describe the electronic health record (EHR) they might expect to see 10 to 15 years in the future. This can be done as a group process or individually. Participants should be encouraged to envision scenarios that are multifaceted and holistic, internally consistent, and free of personal bias. Elements in the scenario should not be contradictory or improbable. A well-constructed scenario may suggest events and conditions not presently being considered.

The following three major approaches can be used to construct a scenario:

1. The Delphi method can be used to elicit expert forecasts for a specific time frame. A combination or synthesis of opinions is used to develop the scenario.
2. Experts develop scenarios that reflect the viewpoint of their disciplines. These are modified and combined to produce an overall scenario.
3. A cross-impact technique is used to test the effect of one aspect of the scenario on all of its contributing parts.

The creation of scenarios can be used in concert with backcasting.

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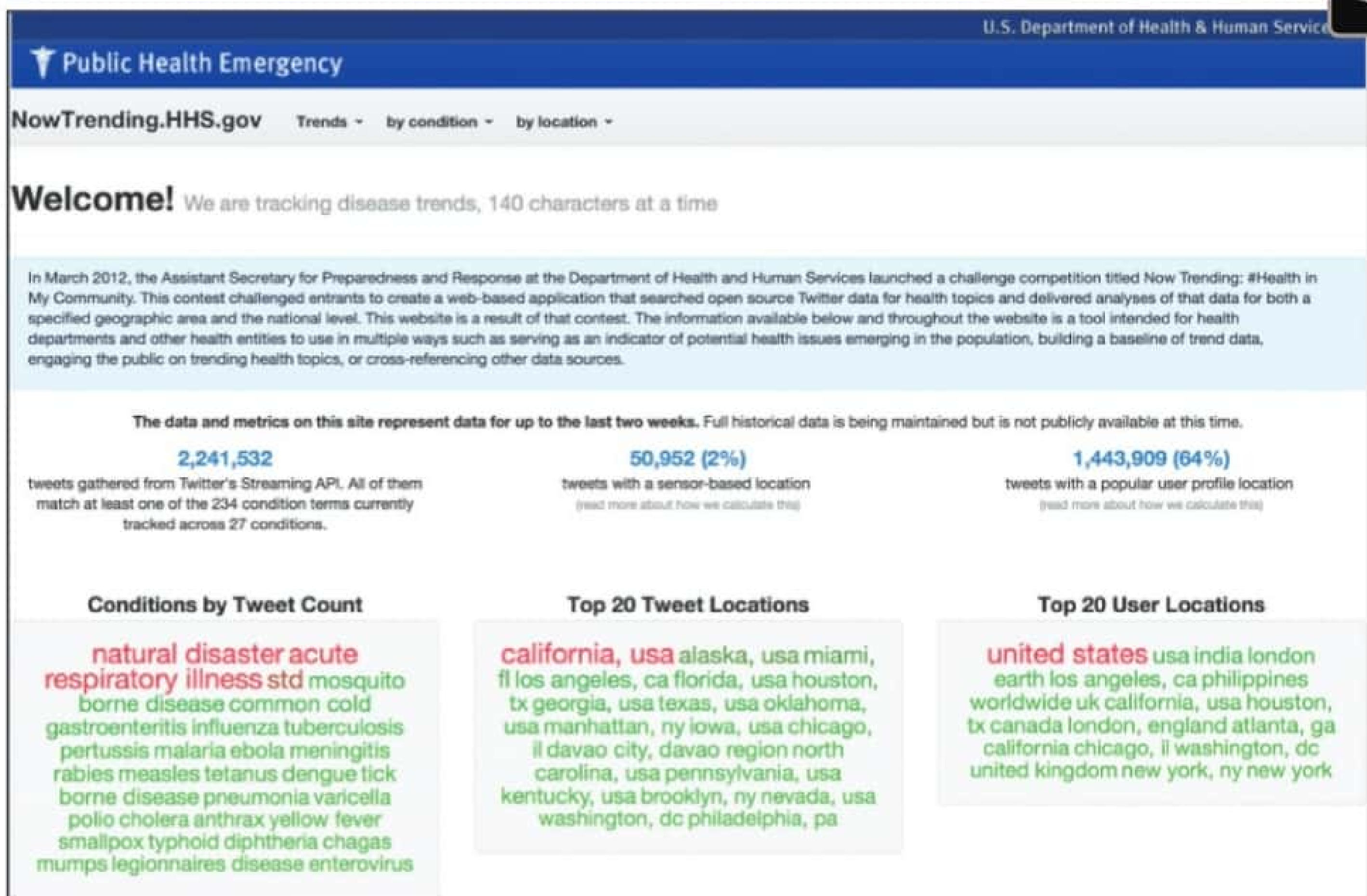

Source: https://nowtrending.hhs.gov

FIG 36.1 What is now trending. Following disease trends 140 characters at a time. (From *U.S. Department of Health and Human Services*. <https://nowtrending.hhs.gov/>.)

Backcasting

With **backcasting**, one envisions a desired future end point and then works backward to determine what activities and policies would be required to achieve that future. Backcasting involves the following six steps:

1. Determine goals or the desired future state.
2. Specify objectives and constraints.
3. Describe the present system.
4. Specify exogenous variables.
5. Undertake scenario analysis.
6. Undertake impact analysis.

The end result of backcasting is to develop alternative images of the future, thoroughly analyzed as to their feasibility and consequences.[13]

With the rapid changes in informatics, the use of futures research methods is likely to increase. Informatics specialists concentrated on implementation and change issues during first generation of EHRs, data warehouses, and mHealth. For the next generations of health IT products, futurology can more readily be incorporated in the health professional or informatician's suite of skills.

Application of Futures Research

Health and informatics professionals can use methodologies and strategies from futures studies in two primary ways. First is foreseeing or predicting future trends and directions. For example, in the 1970s and 1980s, much of healthcare was financed via fee-for-service funding approaches. Health information systems were designed to capture charges but not to measure the cost of care. A number of items, including nursing and other services, are included in the patient's charge for a hospital room. In a fee-for-service approach, the contribution of nursing and other services to the total cost was irrelevant. Cost and charges did not need to correlate. The charge could be whatever the market would bear.

The introduction of the prospective payment system in the 1980s and managed care in the 1990s is now followed by the current value-based approach, Merit-Based Incentive Payment System (MIPS), included with the Medicare Access and CHIP Reauthorization Act (MACRA) of 2015. These initiatives require that healthcare institutions capture costs and quality rather than just charges. Existing information systems were never designed to facilitate capturing discrete costs

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(versus charges). The ability to predict these kinds of major changes in healthcare delivery could be a significant advantage to vendors and healthcare institutions alike. By predicting the potential costs and benefits, one is better prepared to manage these events. Cost-benefit analysis is an example of using futures studies for management.

Creating the future is the second way in which health informatics specialists use futures studies methods. By thinking of possible futures scenarios, health and informatics professionals can work toward creating the environment in which these futures might be possible. By using the work of futurists, as well as applying futures studies methods and tools, it is feasible to imagine possible future trends and directions and thereby work to create preferable future directions.

THE FUTURE OF HEALTH INFORMATICS

Health informatics is and will remain a dynamic and complex field. Thus accurately predicting precise directions for its future is inherently uncertain. To determine likely directions for the future in healthcare and health informatics, the authors searched traditional literature databases, publicly available white papers such as the National Institute of Health's plan for 2016–2020,[14] and reports from major analytic firms such as Manatt's Megatrends Shaping Healthcare 2016–2020[15] and Pricewaterhouse Coopers' (PwC) Top Health Industry Issues,[16] as well as less formal sources such as futures presentations by national and regional experts.

Formal literature does not provide consensus about emerging or future directions for informatics. Authors in the past wrote about the future of academic biomedical informatics,[17] created a nursing informatics research agenda for 2008–2018,[18] and provided an analysis of the past, present, and future of medical informatics[19]; however, none of these was published recently. Within informatics and nursing, major past efforts internationally centered on terminology development.[20] Future trends will certainly include this emphasis but likely will expand into new areas, as outlined in the following discussion.

Looking further into the future can influence thinking about near-term trends. Outside the field of healthcare, contemporary issues of *The Futurist* (http://www.wfs.org/futurist) list annual outlooks. A sampling of trends pertinent to healthcare include the following:

- *Tiny chips.* Computer chips will shrink to the size of dust and be ubiquitous.[21]
- *Huge amounts of transmitted personal health data.* Embedded or swallowed sensors will collect and transmit an array of personal data.[22]
- *New leader skills.* These will be shaped by those with social networking, content management, data mining, and data meaning skills. New job titles will include Chief Content Officer and Chief Data Scientist.[23]
- *Nanotechnology products.* Buckypaper is composed of industrial-grade carbon nanotubes and is 100 times stronger than steel per unit of weight. It conducts electricity like copper and disperses heat like steel or brass.[24]
- *Nanorobots or nanobots.* These carry molecule-si[ze] elements, can detect cancer, and are being developed by researchers at Harvard University.[25]
- *Full-body firewalls.* These are necessary to prevent hackers from tampering with wireless medical devices and internal drug delivery systems. Researchers at Purdue and Princeton Universities are developing a medical monitor (MedMon) designed to identify potentially malicious activity.[26]
- *Ubiquitous computing environments.* Workplaces will become ubiquitous computing environments that include computing capabilities and connectivity.[27] Likewise, homes and personal devices will provide constant communication and computing outside work.
- *Image-driven communication.* Graphics and images will be more heavily relied on for communication, allowing faster comprehension and possibly new ways of thinking, but at the cost of eloquence and precision.[28]
- *Living data.* Connectivity will expand to millions of devices, and sensors will gather more data that will be processed by more computers. Data may become too big, so channeling the power of data will become important.[29]
- *The intelligent "cloud."* This will become not just a place to store data but will evolve into an active resource, providing analysis and contextual advice.[30]

These more futuristic trends are important to monitor, and some inform near-term trends. Near-term future trends are (1) person-centered health and concomitant implications for health informatics; (2) technical trends in health IT such as the internet of things (IoT) and cybersecurity issues; and (3) clinical informatics trends, including what is beyond traditional EHRs, improving the user experience (UX), predictive analytics, and data visualization.

Person-Centered Health and Informatics

An obvious shift has occurred away from provider-centric healthcare toward person-centered health.[31,32] The importance of this shift is underscored in a number of chapters of this book: Chapter 8 (Telehealth), Chapter 9 (Home Health), Chapter 12 (ePatients), Chapter 13 (Social Media), Chapter 14 (Personal Health Records) and Chapter 15 (mHealth). This direction will continue to accelerate over time, although healthcare and informatics will likely see the fusion of several of these separate areas in the future.

The term person-centered health is used as a generic term to encompass ideas about the various terms in use today: person-centered care, patient-centered care, precision medicine, and consumer-centered care. Person-centered care embodies personal choice and autonomy in healthcare decision making.[33] More specifically, this newer term most frequently includes these six principles: (1) whole-person care, (2) respect and value, (3) choice, (4) dignity, (5) self-determination, and (6) purposeful living. They are being applied to the care of older adults in particular.[33] Precision (or personalized) medicine includes a central premise that health interventions are tailored to specific individual differences such as genome, environments,

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and lifestyle.[34] For example, therapeutics would be tailored specifically to individuals' genetic tumor compositions and their responses to previous interventions. In support of research for precision medicine, an initial $215 million investment was recently included in the U.S. budget.[34] No matter the current term, the shift is toward tailoring care to and improved support of health decision making for individuals. This shift has substantial implications for informatics because these areas are highly data-centric. Demiris and Kneale[35] outlined initial informatics support for the move toward person- and patient-centric care (e.g., improvements in clinical decision support, e-tools to support care transitions, PHRs, and telehealth). Two other near-term informatics trends are outlined in support of person-centered health in the future: (1) care anywhere and everywhere and (2) personal data integration.

Care Anywhere

EHRs by design are organization- and provider-focused. The movement toward person-centered health requires rethinking the design of disparate health data into a person-centric format. Aspects of traditional care settings, supported by EHRs and to a lesser extent by PHRs, are evolving into remote, on-demand services for many nonemergent services. Through informatics tools, consumers are supported as they assume more responsibility for their own care, especially consumers with chronic diseases. Informatics support via apps and the internet is expanding at an enormous rate. From 2013 to 2015 alone, mHealth applications expanded fourfold from 40,000 to over 165,000,[36] and on-demand services are easily accessible via the internet (e.g., dermatology).[37] Although the care models of the future are not precisely clear, the move is toward care anytime, anywhere for areas such as primary care and chronic care.

The design of tailored, person-centered applications provides a wealth of opportunities for research and development, including the following:

- Theory-based studies on the impact of person-centered health IT products
- The effectiveness of changing care models on care collaboration for individuals focused on person-centered health

Personal Data Integration

As information in Chapter 8 points out, simple personal monitoring tools such as electronic scales and remote blood glucose monitors are already expanding into a suite of robust biometric sensor technologies. One source indicated that by 2018, 130 million wearable sensors will be acquired by the public.[38] Smart textiles and other personal devices such as smart contact lenses and smart homes in the future could provide constant monitoring of individuals' health and chronic conditions. No doubt many people will be actively monitoring and interpreting their own data from these devices.

Care anywhere and the increase in personal data mandates an amalgamation of pertinent health data beyond a casual level and away from informal personal records or users keeping data in their heads. Instead, these will need to include data integration across disparate sources for an interpretable individual view. Today, mHealth apps and online serv[ices] result in stand-alone data viewed primarily by patients and families. Thus the challenge will be to effect data integration across diverse sources and to provide monitoring with appropriate interventions for any acute changes. Future research and evaluation might include the following:

- Evaluating the impact of role changes from provider-centric to patient-centric data
- Exploring outcomes of the new digital divide among individuals who cannot or choose not to be "quantified" by personal data

Technical Trends

Technical aspects of health informatics are trending toward cloud computing and remote application services, as indicated in Chapter 5. Two other important technical trends are especially relevant for the near future: the IoT and increased cybersecurity threats.

The Internet of Things

Simply put, the IoT refers to a network of connected devices.[39] Currently, the IoT might be used to remotely monitor a patient after discharge[40] or to track equipment or people inside health facilities. In the future, the IoT has broader applications. With multiple devices and people connected via the internet, new applications are possible. A simple application might involve improved remote physiologic monitoring using sensors. For example, flexible and wearable sensors, which adhere to skin better, and silicon-based materials, which conduct signals better, can combine with the IoT to allow improved, remote physiologic monitoring for patients.[41] More complex IoT applications in a facility might include a suite of interacting devices and applications, including:

- Physiologic monitoring across hospital units and areas without equipment changes
- Inpatient assignments coordinated with nurses' experience levels due to the integration of smart staffing and scheduling applications with patient conditions
- Consumable supplies and medications automatically creating their own charges on patients' bills
- Consumable supplies automatically reordering themselves when supplies run low
- Durable medical equipment that automatically appears on units when a discharge order is written

In fact, Gartner estimates that by the year 2020, nearly 26 billion devices will be on the IoT.[42] Trends in healthcare informatics will likely mirror the increase in connectivity via the IoT. Imagine the potential of this kind of capability combined with care anywhere, personal device data, and EHRs. Future research might include the following:

- Evaluation of the timeliness of diagnoses with newer models of data availability
- Changes in provider and patient treatment adherence and monitoring with the IoT data

However, with this expanded connectivity, the available health data increases but so do the risks to health data privacy and security.

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Cybersecurity Threats and Mitigation

One of the most ominous risks in health informatics now and in the future is the increase in cybersecurity threats (see Chapter 26). With the proliferation of devices, their connectivity to the IoT, the increased use of mHealth apps, and the increase in health data posted on social media, cybersecurity threats will only increase in volume and severity. New threats are emerging. For example, hackers cut off health data access at a California hospital and demanded a $3.5 million ransom.[43] All data were affected, from prescriptions to CT scans and even e-mails, forcing the staff to revert to paper methods and potentially compromising patient care. The hospital executives decided to pay a $17,000 ransom in bitcoins to end the incident. These incidences will likely be more prevalent in the future.

The informatics future will surely include more emphasis on health IT security, improved security using thorough risk assessments, and increased fiscal allocations for cybersecurity. A particular emphasis will be on improving the cybersecurity of personal health devices and preparing for the IoT connections. Policies, procedures, and code will be developed to prevent hacking and to avert paying ransoms in the future. Future research might include the following:

- The impact of threats on patients' willingness to share private data such as mental health concerns
- National efforts to combat cybersecurity threats

CLINICAL INFORMATICS

Beyond EHRs 1.0

With EHR adoption rates rising, especially for ambulatory practices,[44] leaders and informaticians are shifting the focus away from basic implementations to other issues such as system optimization and data science (discussed in Chapter 23 and later in this chapter). One of the most common foci is system optimization. The term *optimization* is used for both initial and postimplementation efforts. Users can benefit from applying known principles for project management and systems implementation (Chapters 17 and 19), as well as by using available guides such as Strategies for Optimizing an EHR System[45] from the ONC for Health IT. Optimization, more importantly, includes post-implementation evaluations, ongoing training, and system re-tailoring where needed. Installations obviously do not end with go-live. Many institutions consider EHR installations as continual transformation instead.

Unfortunately, the Health Information Technology for Economic Clinical Health (HITECH) Act did not include funding for research to evaluate the impact of EHRs,[17] so this type of research constitutes a future direction for informatics practice and research. In an editorial for *The New England Journal of Medicine*, Mandl and Kohane argue that vendors propagated a myth of complexity that precludes innovation and that EHRs are different than more flexible and robust consumer technology.[46] The authors' impatience and health IT leaders could drive needed changes for EHRs in the future.

One change might be that vendors no longer are full-ser[vice] providers of EHRs. Instead, they may become smaller service and application providers, allowing sites to pick and choose best options among vendors, including among nontraditional vendors such as Google or Microsoft.

Another approach is described by Celi et al.,[47] who propose the construction of what they call optimal data systems. They recommend a focus on clinical decision making through the collection of data from various sources (Box 36.5). Although UX and data visualization issues would need to be central to development, this approach certainly provides an interesting vision beyond EHRs 1.0.

Newer infrastructures, such as cloud computing, middleware, and mobile applications, could allow more robust integration efforts at the healthcare provider and consumer end of computing. Facilities are already incorporating mHealth apps into their suite of applications, although current statistics indicate only about 2% of patients are using them currently.[48] User demands may force vendors to incorporate newer tools in their offerings, such as more robust clinical documentation tools with integrated graphics and drawing capabilities and even a basic spell-checker, currently lacking in today's EHRs. Previous authors indicated that disruptive technologies for EHRs are needed to displace the current model of EHRs.[46]

EHR interoperability efforts will continue, especially in the United States, where the diversity of products and components has caused the nation to lag behind others in creating integrated, person-centered, and longitudinal EHRs. Regional integration efforts have helped in the effort to share data, although interoperability beyond regions will be a continuous, costly future direction for the U.S. informatics research,

BOX 36.5 Elements of an Optimal Data System[48]

- Automatic collection and display of new data (real-time data), including alternative sources such as prehospital and personal device data
- Capture and integration of new data with historical to visualize trends and determine the current clinical state of the patient
- Integration of clinical decision support systems and Watson capabilities for diagnostic, therapeutic, and prognosis activities
- Use of machine learning to improve the quality of information
- User-tailored views of data
- Data sharing for population management
- Reports on adherence to best practice management
- Flexible system architecture to allow importing new modalities for decision support
- Prioritization of information types to allow urgent information to be incorporated (e.g., epidemics, disaster information)
- Use of user-centered design techniques (prototyping)

Source: Celi LA, Csete M, Stone D. Optimal data systems: the future of clinical predictions and decision support. *Curr Opin Crit Care*. 2014;20(5):573-580.

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and operational efforts on ontologies will continue to facilitate this work. What is urgently needed in the short term is a decision about the use of one or two specific ontologies, versus an endorsement of a suite of competing ontologies, especially for nursing. A more long-term solution may be found in the current research on national language processing and semantic mapping, where the process of mapping concepts can be automated. An early example of this can be seen with the diagnostic reasoning of IBM Watson, where analysis occurs at the cognitive level and does not require consistent use of the exact same terminology.

As is being seen with care anywhere efforts already, the traditional view of EHRs may fade. EHRs may be less organization- and site-specific and may become dispersed with data owners related to their roles (patient, healthcare provider, insurer, lab, pharmacy, etc.). In this case, data are pulled and integrated from geographic or other defined areas. A particular need for the future is more team-based, interdisciplinary views, and collaborations based on EHR data. New visions for EHRs are needed to be more patient-centric (beyond initial PHRs) and to serve as communication hubs.[49] Given the importance of teams in healthcare, the next generation of EHRs, no matter how they are instantiated, should offer collaborative workflow tools and methods for synthesizing data and information for "at-a-glance" views across disciplines, sites, types of agencies, and traditional modules.

Potential areas for future research include the following:

- Evaluative research on the impacts of EHRs from various viewpoints of consumers, healthcare providers, teams, care outcomes, and quality of care
- Impacts of integrative views of patient-centered data across traditional EHR modules and disciplines
- Cost-effectiveness research and comparative effectiveness for EHR designs

IMPROVING THE USER EXPERIENCE FOR HEALTH INFORMATION TECHNOLOGY

Efforts to improve the UX for health IT have now begun after years of relative neglect. More are needed. Leaders are recognizing that UX issues can affect patient safety as well as user efficiency and satisfaction. Healthcare providers deplore the poor usability of today's EHRs. Improving the UX for health IT is an obvious future trend. As noted in Chapter 21, the American Medical Association (AMA) and 30 physician groups wrote to the ONC for health IT about poor EHR usability and its impact on physician productivity and reimbursements.[50] In late 2015, the AMA held two town hall meetings to outline usability issues and subsequently released a framework for sites to gauge the effectiveness of a vendor's user-centered design techniques.[51] Other professions need similar efforts to improve the UX. Within nursing, Staggers et al. issued a recent call to action to improve the UX for health IT for nurses. UX efforts are needed, especially for vexing designs such as care transitions, medication management (Electronic Medication Administration Recordsor [eMARs]), and clinical documentation.[52]

On a more hopeful note, some large health IT ven[dors] have hired UX professionals and are beginning to employ user-centered design techniques like those discussed in Chapter 21. These efforts were incentivized by Meaningful Use requirements. Whether these efforts continue as robustly remains to be seen. At this writing, UX improvements are occurring more slowly for nurses and allied health professionals than for physicians.

What is needed in the future are repositories for excellent designs and solutions to current UX issues. Typically, each site grapples with problems *de novo*, meaning wasted effort across the nation. Excellent, generic designs should be constructed and shared for common applications such as assessments, eMARs, and the like.

Due to current complaints by users, federal UX requirements will likely expand (beyond medical devices regulated by the U.S. Food and Drug Administration), and vendors will have to respond to the need for improved products. Organizations will need to increase their knowledge about and skills for improving the UX. Excellent resources for meeting this challenge are the Healthcare Information and Management Systems Society (HIMSS) Usability Maturity Model,[53] the ONC's SAFER (Safety Assurance Factors for EHR Resilience) guides,[54] and documents from the National Institute for Standards and Technology (NIST).[55] Research directions for improving the UX are many. Examples include the following:

- Comparative effectiveness research on EHR and device designs, especially for complex patient views, such as clinical summaries, care transitions, and eMARs.
- Developing and implementing best design practices agnostic of vendors. Perhaps decoupling user views from underlying code could occur so that optimal designs could be downloaded by healthcare providers and layered onto their local data.
- Determining outcomes for varying application designs. For instance, improved displays can positively affect clinicians' situation awareness and performance in intensive care units (ICUs).[56-58] Similar studies for other applications could be completed.

ANALYTICS (BIG DATA) AND DATA VISUALIZATION

The world is generating mass amounts of data. IBM estimates that 2.5 quintillion bytes of information are generated each day. That is three times the equivalent of the Library of Congress each second.[59] In the life sciences, genomic data have created large datasets for analyses. Bioinformatics efforts are underway to integrate data across disparate fields. For example, the National Center for Integrative Biomedical Informatics from the National Institutes of Health is developing interactive, integrated, analytic, and modeling technologies from molecular biology, experimental data, and the published literature.[60]

Within healthcare, data warehouses combine longitudinal, administration, and financial data into a searchable database,

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although typically at the local or healthcare enterprise level. Now, the boundaries are blurring among personal health data sources: mHealth, social media, wearable and sensor devices, and PHRs,[61] so opportunities for increased data collection are manifest. Thus data from personal devices such as sensor data and mobile and remote technologies could be integrated with EHR data in the near future. Personalized medicine efforts, including genomic data and nanotechnology, promise the expansion of these kinds of databases even further.

With these super-sized datasets, an unparalleled opportunity exists to examine data and issues across thousands of data points integrated across fields (population data, genomics, etc). The challenge is that the ability *to collect* these types of data has outstripped the ability *to analyze* them.[62] Data science was discussed in Chapter 23, and as readers recall, data analytics help in sense making by revealing patterns in datasets. A current trend is the shift from retrospective to predictive analytics.

PREDICTIVE ANALYTICS

According to current national and regional presentations, Chief Information Officers (CIOs) and health IT leaders are moving their foci to predictive analytics. As mentioned in Chapter 23, predictive analytics is the use of past data predict future trends. The goal is to present data to decision makers as close to real time as possible. A simple example might be the real-time analysis of vital sign trends in a patient on a medical-surgical unit to predict the need to call a rapid response team and prevent a code. On a more complex level, the description about the optimal data system for EHRs discussed previously would rely on predictive analytics for decision making about intensive care patients—that is, the system would amass near real-time data from traditional sources like physiologic monitoring and less traditional sources including IBM Watson, analyzing them and displaying data in near real time for care decisions across complex datasets.

From an analytics tools perspective, Shameer et al.[63] depict a model for data integration and subsequent analyses at the individual level (Fig. 36.2). Here, data from different sources would be integrated for uses in person-centered health and precision medicine to provide individualized predictive analytics. This type of real-time analysis is a marriage of EHRs, decision support, and computer science and is being proposed for clinical settings, although it is not yet actualized.[63] As this type of real time analysis becomes available at the individual level, healthcare providers will be challenged to integrate yet more information into their cognitive processes and workflow.

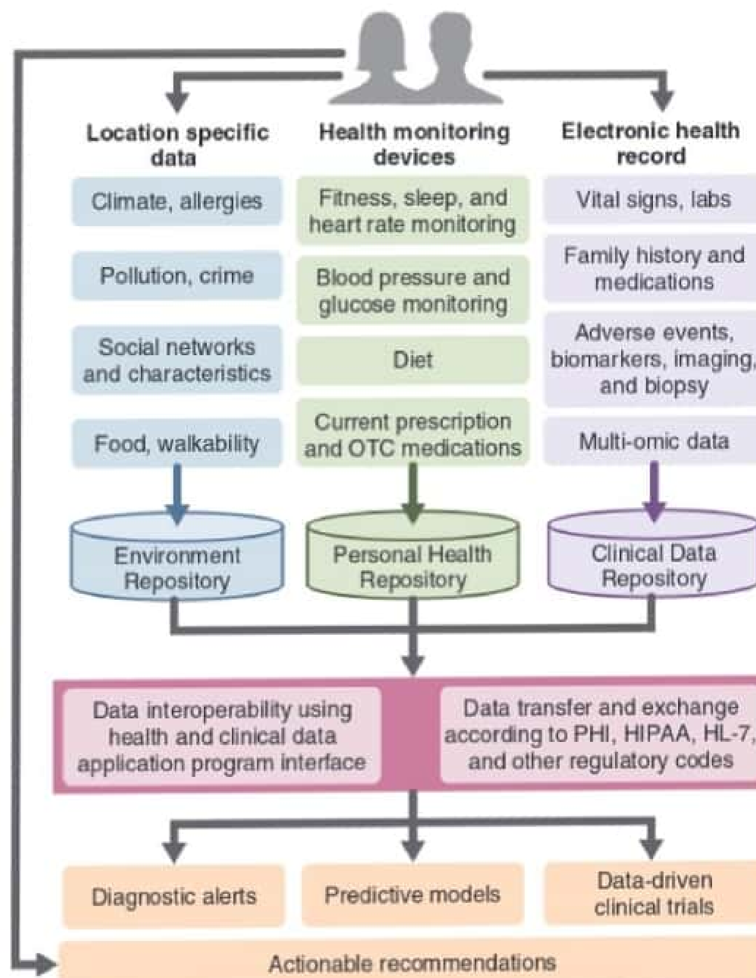

FIG 36.2 Healthcare and wellcare data model. (From Shameer K, Badgeley MA, Glicksberg BS, Morgan JW, Dudley JT. Translational bioinformatics in the era of real-time biomedical health care and wellness data streams. *Brief Bioinform*. 2016, pii: bbv118. Reprinted with permission from Oxford University Press.)

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In other examples, predictive analytics could be useful at the population level in detecting global diseases such as the Zika virus or even in real-time fraud detection for someone attempting to use information to cheat on insurance coverage, much like credit card fraud detection is done today. These kinds of advanced applications are predicated on having quality source data, standards for integration and appropriate integrated data, and a capability of being able to interpret data using tools like data visualization.

DATA VISUALIZATION

One of the pressing issues with analytics is making sense of vast amounts of stored data. Unlike traditional graphs and charts, new methods are being developed outside healthcare. Fig. 36.3 provides an example from biology and computer science. At the intersection of science, design, and data, data visualization involves understanding principles of human perception, design, and computing capabilities.[64]

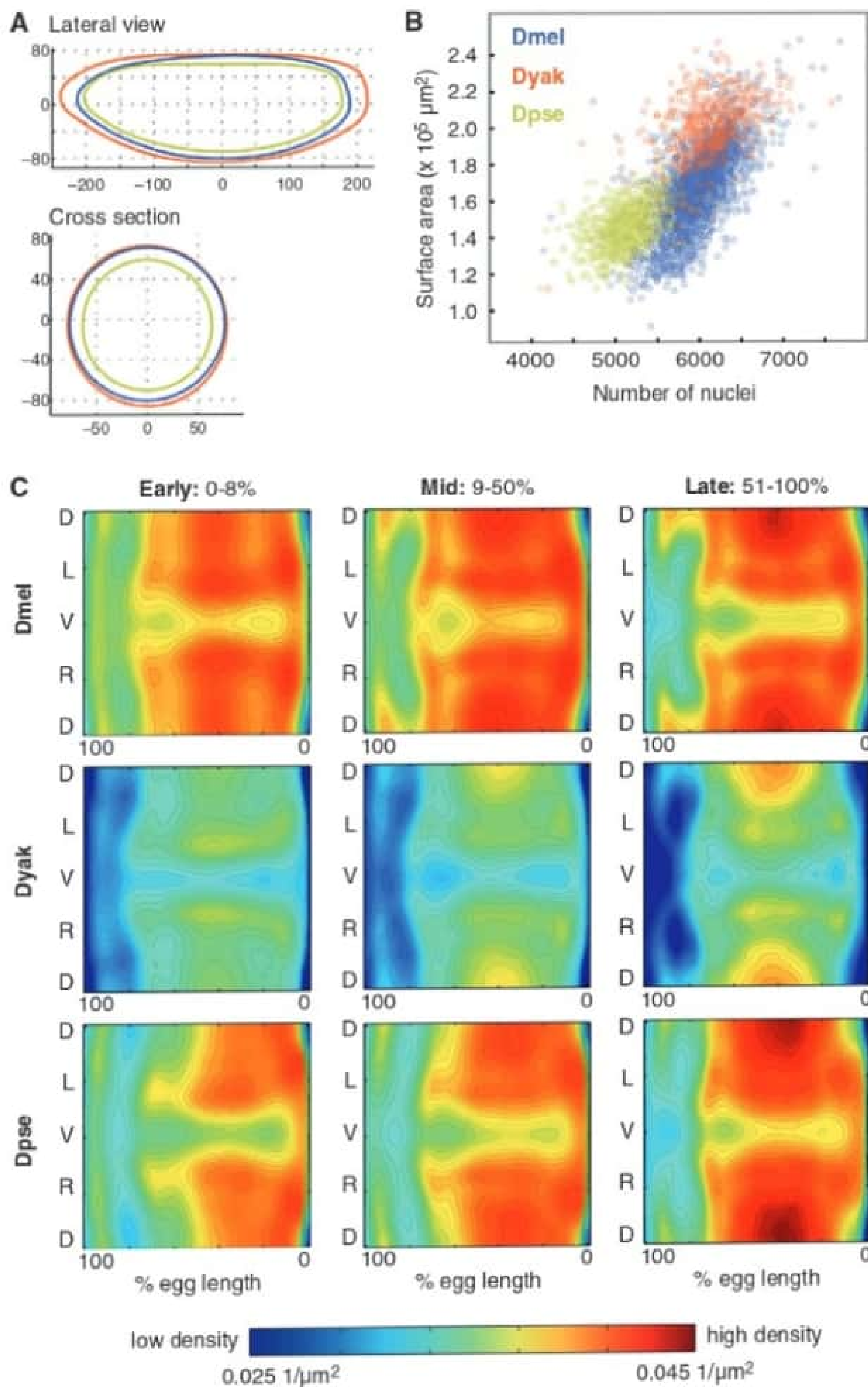

FIG 36.3 Example of visualization tools used to compare fruit fly attributes. (From Fowlkes CC, Eckenrode KB, Bragdon MD, et al. A conserved developmental patterning network produces quantitatively different output in multiple species of Drosophila. *PLoS Genet.* 2011;7(10):e1002346.)

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In the life sciences, interdisciplinary teams of biologists and computer scientists developed interactive visualization tools like MulteeSum to compare genes in fruit flies.[65] In healthcare, analytic tools for searching data warehouses are emerging, but data visualization tools like those from the life sciences are still very limited in their application to health data, and they do not yet exist at the point of care. Because analyzing data and making conclusions from stored data can affect organizational and patient care decisions, data visualization efforts for healthcare will be an important future trend.

Research directions for analytics and data visualization include the following:

- Developing and implementing at the key decision points and interactive visualization tools for health practitioners, especially for nursing, pharmacy, and other healthcare providers whose analytic and decision support needs are often neglected.
- Developing big datasets, combining published literature, population data, and regional data warehouses.
- Detecting patterns for interventions and outcomes in national databases, including databases that incorporate include newer data such as sleep monitoring, metabolic values such as pO_2, and patient-generated fitness data with more traditional EHR data.

Nanotechnology

Nanotechnology is the study of controlling and altering matter at the atomic or molecular level.[66] The focus of the field is the creation of materials, devices, and other structures at the nanoscale (1 to 1000 nm). The produced items are referred to as **nanomaterials**, which are composed of smaller subunits called nanoparticles. Nanotechnology is a diverse field that requires a collaborative environment across multiple domains (e.g., surface engineering, physics, organic chemistry, molecular biology, and materials science).

History of Nanotechnology

Even though the majority of research in the field of nanotechnology was conducted in the past few decades, the field began in 1959 when Feynman presented a lecture titled "There's Plenty of Room at the Bottom."[67] In this talk, he discussed being able to manipulate individual atoms, which would allow for more flexibility and use in synthetic chemistry.

The field expanded in the 1980s with the invention of the scanning tunneling microscope and the discovery of fullerenes, a carbon molecule. With the scanning tunneling microscope, scientists could visualize particles at the nanoscale. In 1985, Kroto and his collaborators discovered a molecule composed solely of carbon, which they named Buckminsterfullerene.[68] Buckminsterfullerene is a spherical molecule composed of 60 carbon atoms. This gives the molecule a high structural integrity and makes it very stable. This discovery laid the foundation for the development of a well-recognized nanoparticle, the carbon nanotube. A carbon nanotube is a nanoparticle composed of carbon atoms bound to one another to form a tubelike structure (Fig. 36.4). Thus carbon nanotubes are a member of the fullerene family of molecules. They have a unique combination of thermal conductivity, mechanical properties, and electrical properties that makes them useful in the development of structural materials like steel.

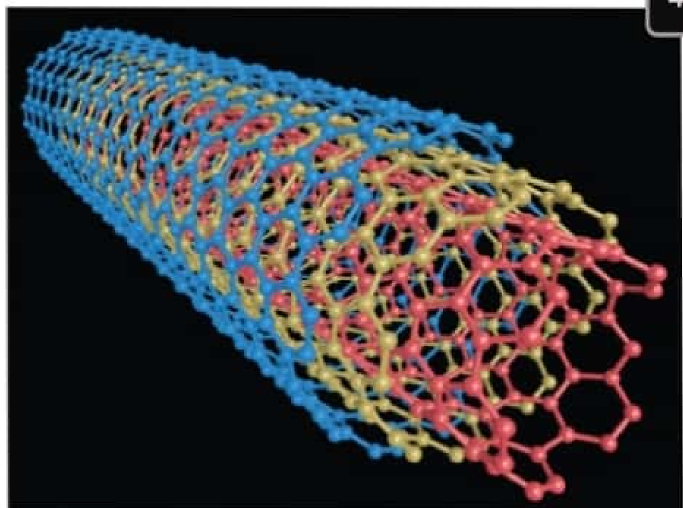

FIG 36.4 A carbon nanotube. (Copyright Owen Thomas/ 123RF Stock Photo. Reprinted with permission.)

Nanofabrication and Nanomedicine

Nanomaterials and nanoparticles are used in electronics, biomaterials, and healthcare. Some claim that this area of science and technology has the opportunity to revolutionize our world. Manipulation of particles at the nanoscale allows the creation of unique materials with special properties (e.g., unique chemical, physical, or biologic properties, such as increased electrical conductivity or strength). The special properties are due to the particles' incredibly small size, which allows absorption or unique movement, and also due to increased surface areas that interact with their environments, creating increased interactions among materials.

Nanofabrication. **Nanofabrication** is the development of materials used in structures, electronics, and commercial products. Fabricated nanoparticles are typically added to larger physical structures to enhance them, resulting in increased strength, elasticity, conductivity, or antimicrobial properties. Much work has been done with carbon nanotubes, because the tubelike structure provides increased material strength. Carbon nanotubes are now commonly used in electronics as wiring for electrical components. For example, a research group at Rice University bound carbon nanotubes to Kevlar fibers to make durable, conductive wires that can be used in wearable electronics and battery-heated body armor.[69] Quantum dots, semiconductor devices whose elements move in all three dimensions, are another nanoparticle often used in electronics as semiconductors.

The number of commercially available items containing nanoparticles has increased at an aggressive pace over the past two decades. When the Project on Emerging Nanotechnologies (PEN) began its inventory in 2005, 212 products

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were listed. The latest inventory in 2015 estimates that more than 1800 manufactured, nanotechnology-enabled products have entered the commercial marketplace; the majority are in the health and fitness category.[70] Items containing nanoparticles are very diverse, ranging from everyday items such as nonstick cookware and lotions to unique items such as self-cleaning window treatments. Probably the most commonly used and commercially available product is silver nanoparticles, due to its antimicrobial properties.

Nanomedicine. Nanomedicine centers on the application of nanoparticles and nanoscience techniques to healthcare and clinical research.[71] Its primary goal is the use of nanotechnology for the diagnosis, treatment, and prevention of diseases. Applications include nanoparticles as delivery devices for pharmaceutics, diagnostic devices, and tissue replacement.[72] Nanoparticles, due to their size and structure, behave differently than traditional particles because they avoid the body's immune defense mechanisms, avoid filtration by the body, and interact more with tissues. Antibodies and a variety of other surface-engineered materials can be conjugated to the surface of nanoparticles, increasing their specificity for individual cell types (e.g., tumors). Importantly, the use of nanomaterials reduces medication dosages and effects on nontargeted tissues. Current research focuses on exploiting the highly soluble, targeting properties of nanoparticles to improve the delivery of cancer drugs to tumor-containing tissues[73] and on using nanoparticles to deliver nonviral genes and small interfering ribonucleic acid (RNA) to combat viruses and cancer.[74]

Another very intriguing area of nanomedicine research is advanced imaging and thermotherapy. Quantum dot nanoparticles are used in conjunction with magnetic resonance imaging (MRI) techniques to produce exceptional images of tumorous tissues. Chemical or physical groups can be attached to these nanoparticles via surface engineering, so that they seek out tumor cells and increase the resolution of images.[75] These same nanoparticles can then be used in the treatment of tumor cells using techniques such as thermotherapy. The process aggregates nanoparticles in tumorous tissues and then excites the nanoparticles using targeted radio waves, lasers, or focused magnetic waves. The excitation causes the metals in these nanoparticles to heat up, raising the temperature of nearby tissues (localized hyperthermia) and causing targeted cell death.[76]

Work is being done to develop in vitro early disease detection methods using nanoparticles. Thus nanoparticles are being used as diagnostic tools. One example is the use of a dime-sized microfluidic device containing a network of carbon nanotubes coated with tumor-specific antibodies.[77] A patient's blood sample passes through the device, and any tumor cells are bound to the nanotubes. Another sensor includes chips containing thousands of nanowires able to detect proteins and other biomarkers produced by cancerous cells. These types of advances could, in the future, enable the widespread detection and diagnosis of cancer in very early stages.

Cautions About Nanotechnology

Even though nanoparticles are incredibly effective and useful, caution is warranted. Unintended consequences of nanomaterials are due to secondary effects, such as cytotoxicity. For the same reasons that nanoparticles are effective (i.e., their size and increased surface interactions), they also can cause toxicity to the environment and humans. This is a key area of concern and current research in the nanoscience and nanomedicine community.[78,79] Many authors discuss inherent toxicity due to nanomaterials' surface charge.[78–81] This surface charge is necessary for cellular uptake. However, if the charge is too high, it can create holes within the cell membranes, resulting in membrane degradation, erosion, and ultimately cell lysis. Clearance of nanoparticles from the human body is another key area of concern, because nanoparticles may be rapidly eliminated by the kidneys or, alternatively, remain in circulation for long periods of time, increasing exposure and potential toxicity.

Synthetic methods such as the use of surface engineering and biodegradable components to construct nanoparticles are being employed to counteract the inherent toxicity of nanoparticles. These processes are used to alter the cationic surface charge of most nanoparticles by reducing the cationic charge, making it neutral or completely changing it to an anionic charge. However, if the surface charge of nanoparticles is reduced too much, the bioavailability of the nanoparticles is also decreased. Because of potential toxicity, nanoparticles must be evaluated carefully before they are approved for routine use in the clinical arena.[81,82]

Nanoinformatics

Nanoinformatics was created in an effort to help manage the large volumes of data being produced by the field of nanotechnology. The foundations for nanoinformatics began in 2007 at the U.S. National Science Foundation. The focus of nanoinformatics is the use of biomedical informatics techniques and tools for nanoparticle data and information. In October 2011, the U.S. National Nanotechnology Initiative (NNI) document was developed, which outlined the following three major goals for nanoinformatics:

1. Enhance the quality and availability of data about nanoparticles.
2. Expand nanotechnology theory, modeling, and simulation.
3. Develop an informatics infrastructure.[83]

The first goal has received the most attention to date. A number of groups are standardizing nanotechnology terms and developing ontologies to represent the relationships among the terms. The two most recognized standards organizations in nanotechnology are the Nanotechnology Standards Panel of the American National Standards Institute and the Nanotechnology Technical Committee of the International Organization for Standardization. The National Cancer Institute leads one of the most well-recognized ontology programs in nanotechnology, the NanoParticle Ontology.

Some progress has been made on the second and third NNI goals. The U.S. National Science Foundation hosts a site named nanoHUB that offers a wide variety of nanotechnology simulation tools for use by the general public and researchers. Recently, 10 federal organizations formed the

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Staffing-Report/Jan.-8-2015/No-more-nurse-shortage-Surplus-projected-for-2025.
8. Association of American Medical Colleges. *New physician workforce projections show the doctor shortage remains significant*. Association of American Medical Colleges; March 3, 2015. https://www.aamc.org/newsroom/newsreleases/426166/20150303.html.
9. Nordlund G. Time-scales in futures research and forecasting. *Futures*. 2012;44(4):408–414.
10. Nelson R. Future directions in health care informatics. In: Nelson SER, ed. *Health Informatics: An Interdisciplinary Approach*. St. Louis: Mosby; 2002:505–518.
11. Toffler A. *Future Shock*. New York, NY: Bantam Books; 1970.
12. Naisbitt J. *Megatrends*. New York: Warner Communication Company; 1982.
13. Goertzel T. *Methods and Approaches of Future Studies*. Camden Computing Services, Rutgers Camden. http://crab.rutgers.edu/~goertzel/futuristmethods.htm; Accessed July 13, 2016.
14. NIH. *NIH-Wide Strategic Plan: Fiscal Years 2016–2020*. National Institutes of Health. http://www.nih.gov/sites/default/files/about-nih/strategic-plan-fy2016-2020-508.pdf. Accessed July 13, 2016.
15. Glaudemans J, Morin A. *The Megatrends Reshaping Healthcare: Managing Change and Maximizing Opportunity*. Manatt, Phelps & Phillips, LLP; December 2015. https://www.manatt.com/uploadedFiles/Content/5_Insights/White_Papers/MEGATRENDS2015WhitePaper.pdf.
16. Pricewaterhouse Coopers. *Top health industry issues of 2016: thriving in the new health economy*; December 2015. http://www.pwc.com/us/en/health-industries/top-health-industry-issues/assets/2016-us-hri-top-issues.pdf.
17. Shortliffe EH. The future of biomedical informatics: a perspective from academia. *Stud Health Technol Inform*. 2012;180:19–24.
18. Bakken S, Stone PW, Larson EL. A nursing informatics research agenda for 2008–2018: contextual influences and key components. *Nurs Outlook*. 2012;60(5):280–288. e283.
19. Haux R. Medical informatics: past, present, future. *Int J Med Inform*. 2010;79(9):599–610.
20. Hovenga EJ. Milestones of the IMIA-NI history and future directions. *Stud Health Technol Inform*. 2009;146:3–10.
21. Yonck R. Connecting with our connected world. *Futurist*. 2013.47(6):17. http://www.wfs.org/futurist/2014-issues-futurist/november-december-2014-vol-48-no-6/outlook-2015.
22. Mesko B. Rx disruption: technology trends in medicine and healthcare. *Futurist*. 2014;48(3):31. https://www.questia.com/magazine/1G1-370319925/rx-disruption-technology-trends-in-medicine-and-health.
23. Colon J. Shakeups in the "C suite": hail to the new chiefs. *Futurist*. 2012;46(4):6–7.
24. Bisk T. Unlimiting energy's growth. *Futurist*. 2012;46(3):31.
25. World Future Society. World trends & forecasts. *Futurist*. 2012;46(3):15–16.
26. World Future Society. Blocking bodyhackers. *Futurist*. 2012;46(4):2.
27. World Future Society. The best predictions of 2011. *Futurist*. 2012;46(1):30.
28. Baines L. A future of fewer words?: five trends shaping the future of language. *Futurist*. 2012;46(2):46.
29. Johnson BD. The secret life of data in the year 2020. *Futurist*. 2012;46(4):21–23.
30. Carbone C, Nauth K. From smart house to networked ho[...] *Futurist*. 2012;46(4):30.
31. Forum LE. *The Future of Healthcare: It's Health, Then Care*. Falls Church, VA: Computer Sciences Corporation; 2010.
32. Voros S, Moreau-Gaudry A. How sensor, signal and imaging informatics may impact patient centered care and care coordination. *IMIA Yearb Med Inform*. 2015;10(1):102–105.
33. Kogan AC, Wilber K, Mosqueda L. Person-centered care for older adults with chronic conditions and functional impairment: A systematic literature review. *J Am Geriatr Soc*. 2016;64(1):e1–e7.
34. The White House. *FACTSHEET: President Obama's Precision Medicine Initiative*. https://www.whitehouse.gov/the-press-office/2015/01/30/fact-sheet-president-obama-s-precision-medicine-initiative; 2015.
35. Demiris G, Kneale L. Informatics systems and tools to facilitate patient-centered care coordination. *IMIA Yearb Med Inform*. 2015;10(1):15–21.
36. IMS. *Patient Adoption of mHealth. Use, Evidence and Remaining Barriers to Mainstream Acceptance*. IMS Institute for Healthcare Informatics; 2015. http://www.imshealth.com/en/thought-leadership/ims-institute.
37. iDoc24. *Ask an online dermatologist*; 2016. https://www.idoc24.com/.
38. Sopher J. *Hot Health Care Trends for 2015: Eye Imaginations*; 2014. https://blog.eyemaginations.com/hot-health-care-technology-trends-2015/.
39. Morgan J. *A Simple Explanation of the "Internet of Things"*. Forbes; May 13, 2014. http://www.forbes.com/sites/jacobmorgan/2014/05/13/simple-explanation-internet-things-that-anyone-can-understand/#11e461cc6828.
40. Harpham B. *How the Internet of Things is Changing Healthcare and Transportation*. CIO; July 2, 2016. http://www.cio.com/article/2981481/healthcare/how-the-internet-of-things-is-changing-healthcare-and-transportation.html.
41. Khan Y, Ostfeld AE, Lochner CM, Pierre A, Arias AC. Monitoring of vital signs with flexible and wearable medical devices. *Adv Mater*. 2016;28(22):4373–4395. http://dx.doi.org/10.1002/adma.201504366.
42. Gartner, Inc. *Gartner Says the Internet of Things Installed Base Will Grow to 26 Billion Units by 2020*. Press Release: Gartner Newsroom; December 12, 2013. http://www.gartner.com/newsroom/id/2636073.
43. Siwicki B. *Hollywood Presbyterian Declares Emergency after Hackers Cut Off Data, Demand $3.$ Million Ransom*. Health IT News; February 16, 2016. http://www.healthcareitnews.com/news/hollywood-presbyterian-declares-emergency-after-hackers-cut-data-demand-34-million-ransom?mkt_tok=3RkMMJWWfF9wsRonua7Leu%2FhmjTEU5z16ewsXaayg4kz2EFye%2BLIHETpodcMTcFhMrzYDBceEJhqyQJxPr3MLtINwNlqRhPrCg%3D%3D.
44. CDC. *Adoption of Certified Electronic Health Record System and Electronic Information Sharing in Physician Offices: United States, 2013 and 2014*. Centers for Disease Control; January 2016. NCHS Data Brief No. 236, http://www.cdc.gov/nchs/data/databriefs/db236.htm.
45. NLC. *Strategies for Optimizing an EHR System*. National Learning Consortium. Office of the National Coordinator for Health IT; 2014. http://www.bing.com/search?q=EHR+optimization&form=PRHPR1&src=IE11TR&pc=EUPP_HRTS.

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