



# COMPUTING AND HEALTHCARE: NEW OPPORTUNITIES AND DIRECTIONS

Workshop Report



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## A CCC SPONSORED WORKSHOP FINAL REPORT

Transformative innovations in health and healthcare will require deep collaborations between health and computing researchers to harness increasing availability of health data, the ubiquity of powerful, networked sensors and computing devices, and the increasing competency of methods and algorithms for analyzing data to provide insights, diagnoses, predictions, and recommendations.

Catalyzing new connections between and among medicine, social and behavioral science, public health and computing will help to enhance individual and population health and promote healthy living—on the path to a health system that is agile, oriented to evidence-based health outcomes, capable of achieving improved chronic care, and that leverages the pervasive availability of computing technologies.

The goal of this symposium was to bring together these diverse communities in order to foster learning, discussion, and ultimately collaboration among them. Through these conversations, we hoped to identify fundamental barriers to progress, define new frontiers and opportunities for computational research in healthcare, and debate methods for leveraging these efforts to promote the highest possible impact.





## PROGRAM RATIONALE AND OVERVIEW

Computing and healthcare (C&H) has been receiving a great deal of attention in recent years. For example the Institute of Medicine (IOM) Roundtable on Value & Science-Driven Healthcare has issued a series of reports, the most recent of which, “Best Care at Lower Cost: The Path to Continuously Learning Healthcare in America” provides a list of recommendations, many of which involve the integration and/or innovation of computing for healthcare research, delivery, and assessment.

One of the challenges in C&H is the segmentation of the multiple relevant communities, including biomedical informatics, computer science, clinical medicine and public health. As part of its continuing efforts to advance computing research, the Computing Community Consortium organized a workshop, entitled Computing and Healthcare: New Opportunities and Directions led by Beth Mynatt from Georgia Tech and Greg Hager from Johns Hopkins University, and co-organized with Christopher Chute (Mayo Clinic), Deborah Estrin (Cornell University), Susan Graham (University of California, Berkeley), Eric Horvitz (Microsoft Research), Kevin Johnson (Vanderbilt University), and Kevin Patrick (University of California, San Diego). The goal of this workshop was to take steps toward bringing these communities together with an eye to unleashing the potential of cross-community collaboration.



Dr. J. Michael McGinnis, Senior Scholar at the IOM, opened the symposium by providing a compelling perspective on the current and future challenges of healthcare in the digital age. Officials from National Science Foundation (NSF) and National Institutes of Health (NIH) provided their perspectives on the challenges and opportunities from their perspective, and affirmed their desire to collaborate in bringing the communities together.

The remainder of the symposium was organized around three themes:

1. Exploiting Data in Abundance,
2. Creating Systems for Collaborative Care, and
3. Focusing on Patient Engagement.

Cutting across these themes were a focus on systems-level approaches, and on the exploitation of population level thinking that moves beyond the confines of the traditional healthcare apparatus.



Panel presentations and discussions were organized to frame the three themes of the symposium. Subsequent breakout groups discussed a variety of more focused topics, all with the goal of answering four key questions:

- 1) What are un(der)recognized, poorly understood or unrealized opportunities for enhancing healthcare using advances in computing coupled with system-scale (re)engineering?
- 2) What are fundamental technical and non-technical barriers to making progress on the above?
- 3) What are the basic and applied scientific questions that these barriers pose?
- 4) How can we measure progress, and what “instrumentation” of the healthcare system would be necessary to measure that progress?

Over 100 individuals representing a spectrum of disciplines participated in the workshop (see demographic breakdowns in Appendix A). Each of the breakouts contributed to a workshop wiki, providing a record of discussion that helps to define a road map of objectives that promises to strengthen a larger community of efforts in Healthcare and Computing.

The remainder of this report reprises the major findings of the workshop organized by the three major themes.

# EXPLOITING DATA IN ABUNDANCE

*Organizers:* Kevin Johnson (Vanderbilt University), Eric Horvitz (Microsoft Research),  
Greg Hager (Johns Hopkins University)

*Panelists:* Suchi Saria (Johns Hopkins University), Madhu Reddy (Pennsylvania State University),  
Gregory Abowd (Georgia Tech), Tanzeem Choudury (Cornell University)

- 1) What data are available from existing sources, what are new data sources coming into being, and what are potential sources of data that are not yet available?
- 2) What areas of healthcare have high potential to be revolutionized using data analytics, and what is the impact: cost savings, better outcomes, improved safety?
- 3) What are nontraditional, population scale opportunities?
- 4) What are key issues/questions and what is a roadmap for addressing them?

## Breakout Topics:

- Population-level health
- Inpatient care
- Outpatient care
- Mental Health
- Wellness and staying healthy
- Legal and social issues

## Summary of Findings

The first session focused on the acquisition and use of data. The availability of data was one of the dominant themes, particularly in the opening panel. Over the past few years, the amount of digital health-related data that is available from both traditional and nontraditional sources has grown with remarkable rapidity. On the one hand, the healthcare enterprise is rapidly becoming a digital enterprise built on a central framework of electronic patient records that is complemented by digital data from a growing variety of sensors and monitors. On the other hand, new consumer devices and social and mobile apps are beginning to amass considerable collections of data acquired “in the wild.” This points toward a future where each person provides a “lifestream” of health-related data, punctuated by occasionally deep and rich data “wells” acquired when in deeper contact with the healthcare enterprise.

The opening panel reflected many of these ideas. Abowd talked about the growing ubiquity of data sources, pointing out that the challenges are really in gathering and exploiting the data. Choudhury extended these ideas to data aggregated over populations and communities—the opportunities for public as well as individualized health. Saria focused on data in the acute care setting, emphasizing the synergies of high-quality, detailed data in those settings juxtaposed against the less rich but ubiquitous data acquired in unstructured settings. Reddy talked to the use and quality of data—how it can be used effectively, how it might catalyze conversation and collaboration in healthcare.

To this latter point, one of the recurring theses of the panels was that gaining *access to data is not equivalent to acquiring insights and understanding*. In short, data by itself does not have immediate value. Multiple challenges stand in the way of making data useful: as one of the panels noted, data must be *easily understood, actionable and relevant*. To achieve this goal, many problems need to be solved, including:

- 1) **Data heterogeneity:** Data is most useful if it is correct, complete and consistently reported. Unfortunately, this is not the case in the real world, particularly for data acquired outside of the healthcare setting. Thus, understanding ways to assess *data quality* and act in accordance with data quality is a crucial problem.
- 2) **Data relevance:** Data needs to relate to the problem or question at hand. 90% of the available data may be irrelevant, yet identifying the “right” 10% may be very hard. Furthermore, data has to come from an appropriately representative population in order to be predictive of a new individual or group. This may need to happen online, and may change for each individual case, providing new computational and statistical challenges.
- 3) **Data linkage:** Often, data sources must be *linked*. But, data linkage introduces inherent issues of data privacy and sharing. As noted by one panel, *data linkage is the holy grail and the fiery lake!* New approaches to security, privacy, and anonymity will be required to make this possible.
- 4) **Data fusion:** There are new frontiers in data science that do not rely on traditional population data but instead correlate a rich pallet of individual traits and attributes with general disease models. For example, how can genomic, behavioral, and psychological data be combined for an individual so that this data informs daily management of a chronic disease.
- 5) **Data accessibility:** Finally, data must be accessible to researchers. Current regulatory hurdles and liability concerns greatly limit our ability to move forward with data-intensive computational research problems.

A separate thread of investigation relates to the broader use of data within the healthcare system. Different participants in the system require different levels of access, and different levels of interaction with patient and population data—patients, family, nurses, primary care givers, and specialists all have unique needs. Yet, the inferences made in each context must be consistent and explainable at all other levels. *Understanding and translating privacy needs across different user contexts is essential for effective use of data.*

Another question that surfaced after the panel presentations focused on the myriad highly downloaded but not rigorously tested mobile health applications. Attendees expressed concern about this phenomenon from a number of perspectives. On one hand, the audience was excited about the ways these applications penetrate environments where data are in abundance, but where access to these data has been problematic. Two such examples are home administration of medications and nutritional content of individual diets over time. These examples represent bridges to isolated islands of data that might inform health decisions. On the other hand the applications that generate these data may be neither reliable nor interoperable in any meaningful sense, making the data either untrustworthy or valueless. Panelists and audience members discussed how and whether to integrate this army of part-time developers into larger national efforts, so that patients are not receiving inappropriate advice or inappropriately high expectations and low value for their time and money.



One of the larger open questions relates to the acquisition and use of subjective observational data within the larger context of data-driven assessment and diagnosis. For example, in a mental health setting, a caregiver may observe certain types of behavior. Such observations are often qualitative, and may have meaning only within a restricted clinical context. Likewise, diagnosis and therapy may also be qualitative, and may rely on the ability of a caregiver to contextualize recommendations based on the needs and ability of the patient. How should these judgements be coupled with objective data-derived assessment? *Computational inference and human judgment should operate in a complementary manner, and inform each other in provably beneficial ways.*

Design, evaluation, and iteration pose immense challenges in healthcare contexts. Most healthcare enterprises are not able to support rapid innovation and evaluation. Thus, we need to develop “living labs” within healthcare where we can quickly understand problems, develop solutions, and evaluate them in realistic settings. *It would be beneficial to establish national centers for healthcare innovation to host data-intensive health research.*

A secondary value of establishing several national centers of this form would be to develop a culture of research and collaboration around health and healthcare computing. As noted in one panel, “tech has to disown tech, and medicine has to be willing to generalize.” That is, innovation has to be in service of a concrete problem, but tools must address the broader generalities of the problems faced in healthcare computing.

A third very important benefit would be to provide a vehicle to move beyond proof-of-concept to studies of efficacy, which are rarely carried out in basic research settings.

National centers could serve a fourth purpose: to establish data standards. Currently, devices and systems within healthcare do a poor job of interoperating, and have almost no economic incentive to do so. As a result, many data archives require substantial investment by individual investigators to develop interfaces, and to curate the resulting data to be in a form appropriate for use. *Creating standardized interfaces, data sets, and associated challenge problems could alter the landscape of healthcare computing research.*



## COLLABORATIVE CARE

*Organizers:* Christopher Chute (Mayo Clinic), Susan Graham (University of California, Berkeley)

*Panelists:* Rob Kolodner (Open Health Tools), Connie Delaney (University of Minnesota), Kay Connelly (Indiana University), Bill Stead (Vanderbilt University)

- 1) What is a model collaborative care network, and what positive (and negative) roles can computing play?
- 2) What will be future interfaces for patient, provider(s), and what role do various healthcare organizations play?
- 3) What constitutes measureable progress in this area; how can we “instrument” the healthcare system to provide the data necessary for assessment?

### Breakout Topics

- User Interface, Human Computer Interaction (HCI)
- Health Information Exchange, data standards and methods
- Data granularity and interoperability
- Shared Knowledge, workflow, and decision support
- Longitudinal data, linkage, aggregation

### Summary of Findings

Healthcare has historically developed as a network of specialized islands of care. This is true for both the type of care, e.g., in-patient vs. out-patient, diagnostic vs. interventional, etc., as well as specialties within a broad area, e.g., cancer, vs. cardiopulmonary vs. mental health. Although specialization is necessary, it also presents a number of challenges and opportunities to bridge among specialists and between institutions to enhance and specialize care for each unique individual.

The opening panel addressed many aspects of collaborative care. Echoing the previous session, Stead discussed turning the collaborative relationship on its head by leveraging an individual’s sensor rich environment and “whole system” pattern recognition to create life management aids. These aids would visualize trends, potential for change and actionable steps. They would link in healthcare when appropriate, proactively targeting clinician interaction to areas of concern. Delaney discussed new models for collaborative person-centered care, with a focus on a community health model. The key would be the development of strong partnerships between academic and community centers, both enhancing the outcomes of healthcare in those centers, and engaging the academic community in real-world problems that care providers face on a daily basis. Connelly spoke to bridging the divide between the traditional caregivers and the patient’s community—friends, family and social organizations. One large challenge is to determine how information, responsibility, and communication are determined in each unique patient situation. Finally, Kolodner extended this view even more, considering both national and international opportunities to create health care networks. As he notes, it is easy to perform suboptimally by focusing on a particular aspects of medicine, potentially at the detriment of others.



An immediate observation was that all these speakers addressed the need for integration, albeit at differing scales and scopes. To achieve meaningful data integration, the importance of *data interoperability*—manifest and comparable and consistent data—was recognized.

The subsequent discussion explored these ideas in greater depth. The challenges to seamless data interoperability are manifold—data is acquired by different healthcare providers in different settings by devices manufactured by different companies. Technically, there are challenges as to what type and granularity of data is available and how; from a regulatory perspective there are challenges related to data quality, provenance tracking, and privacy. Further, the ultimate uses of the data are not clear, making the governance of data difficult to define. In short, *who “owns” the data, who are they allowed to share it with, for what purposes, and who bears the cost?* These are not technical problems *per se*, but ones in which federal help, in collaboration with the research community could reap enormous benefits.

Coordinated care is likewise a complex knot to unravel. As noted previously, the current organization of healthcare allows for a clear delineation of role and responsibility: “my job is to treat this patient for XX.” There are enormous headwinds to *change*—*nearly all of the healthcare education, delivery and payment system is organized around this model; a fact long recognized as a misalignment of incentives among payers, providers, and patients. Creating a patient care “clearing house” that consolidates patient care into a single unified view would be a significant step toward seamless care coordination.*

The panel considered two elements of a path forward. The first is to focus on the broader notion of health, not just healthcare; the second is to emphasize coordination “at the boundaries,” with a clear delegation of health management as a patient moves through the system. There are a number of interesting technological problems that arise in supporting this model, but as with data interoperability, these technological shifts will also require some level of regulatory shift. Echoing, the previous session, an intermediate step may be *the establishment of national “collaboratories” where these ideas can be explored in the small, using an IRB-like model, but at a health system scale.*

Shared knowledge and integration is an essential enabling technology for any type of collaborative care. By collecting information on the patient in his/her natural environment and reporting data in the context of the patient's norm values, the data provided to the clinicians has significant higher value. This theme and the need to share data in the context of the patient's physiologic historical state was a strong theme of the Shared Knowledge, Workflow and Decision Support breakout.

Another breakout discussion focused on sharing information across various types of people, including different provider and patient populations. The barrier to sharing caused by the siloed nature of existing clinical information was discussed, and the complementary need to curate data sharing and annotation schemas (or standards) was raised. Touching upon something said in the panel sessions, there are significant liability issues related to data shared in a format that makes access difficult or impossible (such as images of documents that are not indexed and searchable). *One mandate of data sharing is that data have to be easily accessible and searchable, otherwise sharing only adds cost and does not add value.* One participant focused on the risks of sharing indiscriminately—e.g. telling a patient that he or she has increasing blood pressure readings that are still in the normal range but may become abnormal in the near future may cause stress and suffering without adding value.



It is easy to focus on care at a time point, but in fact, health and healthcare extends over the entire lifetime of an individual. The breakout group on longitudinal data considered the issues of longitudinal data in the context of the goals of using these data to manage health and care over a lifetime. Management includes chronic care, crisis care, and behavioral interventions. The data should support proactive actions, should classify a patient as to what “state” they are in, should provide estimates of risks of future states, should provide real-time science (what do we know now that applies to you). The data need to be captured and viewed as time series—data across time—so as to enable analysis of trends, to include non-clinical data, to include routine and research data, to acquire meaning through external data, ancillary data, geo data, and labeling. In many cases, final diagnoses may not be included in the electronic records for a specific inpatient visit as diagnostic coding is done after patient discharge; this linkage must be made. Use of non-standard and time-series data requires new theories of evidence and methods for integration and research.

A discussion of OpenRecords (capabilities in which a patient can view and edit his or her own documentation) focused on the improved quality of the information, but also raised concerns of ability to understand and interpret data. A discussion on note summarization resulted in the sentiment that note summarization may have great potential to take extended forms of documentation from multiple sources and summarize and translate to different levels of expertise, which may then be used to integrate in other documentation. *There was consensus that methods in computer science may be harnessed to provide significant value in providing general-purpose information summarization technologies.*

The discussion culminated in some consensus research questions:

- 1) What data is it important to share and with which groups (provider to provider, patient to provider, across specialties)? There is a need to evaluate the impact of data elements on outcome variables.
- 2) There need to be methods for decision support on shared data that enable decisions of social relevance, high urgency, and actionability. Examples include Who will die? Who will be readmitted? Who will commit suicide?
- 3) There need to be ways to facilitate sharing on the different levels and time scales of discovery and action. Data - information - knowledge - decision - treatment.

There are a variety of actions that could move these efforts forward. One immediate goal could be to first identify, in concrete terms, the end uses of such data, and, from that, the data that should be acquired to support it. Conversely, rather than needs driven work, creating a large-scale (thousands of individuals) testbeds could provide a focal point for creative thinking and work in this area. Finally, much could be learned from the experience of Scandinavia where longitudinal data already exists.

In summary, sharing raw data has much less value than extracting information that is then tailored to the needs of the individuals and groups that have been granted access to the data. In this regard, a concept from the first session was reiterated: *Clinicians need information that is actionable and is delivered to them before they know that they need it.*



# PATIENT ENGAGEMENT

*Organizers:* Kevin Patrick (University of California, San Diego) Deborah Estrin (Cornell Tech), Elizabeth Mynatt (Georgia Tech)

*Panelists:* Maja Mataric (University of California Southern California), Katie Siek (University of Colorado at Boulder), Bonnie Spring (University of Colorado at Boulder), Susan Bakken (Columbia University)

- 1) What are the technical and methodological barriers to extending care beyond traditional healthcare boundaries, with an eye toward pro-active care?
- 2) How can this system be used to engage patients, family, groups of patients, and entire populations?
- 3) What constitutes measureable progress in this area; how can we “instrument” the healthcare system to provide the data necessary for assessment?

## Breakout Topics

- Interaction design
- Mobile health technologies and approaches
- Disparities—designing for diversity
- Behavior and attitude change: theory and design
- Social engagement—activating the social sphere

## Summary of Findings

The panel discussion in patient engagement centered on the opportunities and challenges related to human use of systems and devices, and how attitudes about health and technology shape acceptance and influence health outcomes.

Social biases and stereotypes play a large role in this discussion. Siek explored the juxtaposition of the abstract model of a “patient” vs. the often unexpected behavior of real “people,” illustrating the difficulty in capturing statistical abstractions that adequately represent real-world interaction. Mataric made a similar point, namely, that there is also a tendency to stereotype acceptance by age, technology literacy or similar “common sense” demographics. There is intriguing evidence that factors such as embodiment (e.g. a robot vs. a graphical interface) play a strong role in acceptance, but there is little support for broader and exploratory studies of this nature. *Overall there is a scant evidence base to inform the potential of computer-mediated health interventions in terms of the applicability of these interventions for different user populations. This evidence must be developed.*

Both Spring and Mataric pointed out that using technology to effect long-term change in behavior is still poorly understood. Researchers are relying on the traditional behavior change literature but demonstrating clinical outcomes in chronic diseases such as diabetes, heart disease, asthma and conditions related to obesity is difficult for healthcare as a whole. Computing research adds the challenge of also understanding how interaction with a device or interface influences behavior.



Spring expanded on the discussion of behavior change, showing data indicating that the broader social environment plays a strong role in engagement and behavior change. Technology can help to engage and present social support. However social support can range from caregiver support to collaborative support (i.e. buddy) models to interventions that foster competition. Many questions remain regarding how and when social support is a key factor in facilitating healthy behaviors and improving health outcomes.

The breakout group on behavior and attitude change expanded on this point. The participants felt that social support is a key factor for engaging consumers of health care at all levels. They also explored other motivations for behavior change, and the role technology could play in both bringing about change, and measuring or assessing that change. However, as the opening panel noted, there is a disconnect between “traditional” theories of behavior and behavior change and new possibilities that have appeared in only the last few years.

For example, can one “prescribe” an app? How is the data acquired by the app to be used? What constitutes a real “measurement”? How to create a research cycle that combines design and ergonomic evaluation with behavior science research and, eventually, the use of technology in the wild? These are issues that should rise to the top of funding priorities. *A common point of discussion was the need for the research community to identify intermediate measures that could be used to assess and compare approaches for facilitating behavior change.* Measures would capture the many factors of behavior change: attitudes, beliefs, daily actions, engagement and learning. Success along these intermediate measures is frequently required for the long term, sustained behavior change that would drive health outcomes.

The breakout group on interaction design focused on four issues, some of which are future research directions and some are issues facing the health and healthcare communities in building usable, effective interfaces.

**1) We need to develop interfaces that have richer situational awareness:** The next generation of health applications and mechanisms for accessing healthcare data must deal with a large volume of data and present information selectively to the user. The form and content of this presentation should make use of contextual information based on the user's role within the care network, the user's level of education, training and experience, the choices available to the user within the constraints of their lifestyle, availability, and other factors.

**2) We need to generalize what is learned from one interaction design to other design problems:** Most current designs are based on user studies and are specific to that application and interfaces (and often the individual user). Further research might take the form of general principles for interactive design, guidelines for effective design strategies, or a common platform for the deployment and testing of applications. As part of this effort, we should encourage the integration of application designs so that user attention can be effectively managed.

**3) We need incentives to reward good design:** The current state of design for most health and healthcare systems is substantially worse than interfaces designed for other sectors (e.g., transportation). We currently lack incentives (either within the research community or through industry) that encourage effective user-centered design.

**4) We need to bridge the funding gap for evaluating technologies that are unique to health and healthcare:** Good design relies on being able to tightly integrate interface development with user evaluation. It is



difficult currently to fund this kind of research—NSF views evaluation of technology dealing with healthcare as part of NIH's mandate, while NIH views technology development as part of NSF's mandate. This gap does not exist in other technology areas.

Discussions on mobile computing reflected the need to codify best practices. The majority of health apps currently available are of questionable value—some might even be dangerous. We are being faced with the challenge of developing tools for effective, safe mobile health applications and providing guidance to help adopters to make appropriate choices. *Researchers in the computing sciences need to collaborate with clinical investigators to establish the design constraints for creating effective interventions that engage people and motivate healthy behavior.*

Finally, the group on social engagement expanded on the theme of enabling social communities to grow around health and healthcare-related topics. These are entirely new spheres that, in many ways, have outstripped “traditional” scientific approaches. For example:

- 1) Technological platforms move quickly. Traditional health studies (RCTs) don't. Also, the needs of commercial providers of those technology platforms may not align with research.
- 2) More research is needed to see if connected patients (connected via technology) have better outcomes as compared to standard of care. But, there may be a sample bias in the people who choose to connect to others using technology. What do the other X% need?
- 3) Instruments traditionally used to measure health outcomes don't always translate neatly to online environments, particularly patient driven environments. New validated instruments and data collection methods are desperately needed.
- 4) Providing interesting nuggets of information can increase response rates for questionnaires. What is the effect of social comparison when data collection instruments provide feedback on self-report data of others (e.g. "you are like 35% of other patients")? Is there response bias? If so, what is the nature of it? Is there a way to provide feedback that is useful for "stickiness", but does not bias data accuracy/scientific interpretation?

A final point is that in the end, patient engagement takes place in an economically governed setting. Providers will offer a service if there is economic gain; patients will accept new forms of engagement if the perceived value is greater than the cost. Insurance companies and healthcare providers will want to be able to assess the benefits of technology relative to other forms of engagement and care.



## CONCLUSION

The Symposium on Computing and Healthcare aimed to bring together leading scientists from multiple related fields to address opportunities with computing and healthcare, inviting perspectives and collaboration from people from clinical medicine, behavioral healthcare, public health, and several subdisciplines of computer science. We challenged participants to reflect about the problems and opportunities ahead with creating more agile, evidence-based healthcare, by leveraging the growing power and pervasiveness of computing methods and technologies.

As can be seen from the summary, several key assessments and recommendations came into focus during presentations, panels, and breakout conversations, as detailed in the report. Key points include the following observations:

- 1) Creating widely available and uniform data standards and data sets, tied to clear healthcare objectives, would help both to define the field, and to simultaneously move it forward in a concrete manner.
- 2) Coordinated patient care will rely on the development of new and highly nuanced information-sharing and decision-making tools that support healthcare at all several levels, from patient to support network to doctor, payer and provider. These tools must expose information for valuable uses while protecting privacy.
- 3) The endeavor of designing for mobility, interaction and engagement of patients and the broader population is an exciting new area that deserves substantial support and attention. An important goal is to create tools that enable the healthcare community to create their own patient-centered designs, with rapid iteration of design cycles integrated into the overall assessment and validation process.

Beyond these immediate needs and goals, the range of discussions during the symposium made it clear that we should strive to achieve a broader and more integrated perspective of activities in this area. Creating recurring venues, such as the meeting we organized, so as to promote continuing discussion and dialog, should be a goal of the research community and, by extension, the agencies that support work in these areas.



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## COMPUTING AND HEALTHCARE: NEW OPPORTUNITIES AND DIRECTIONS

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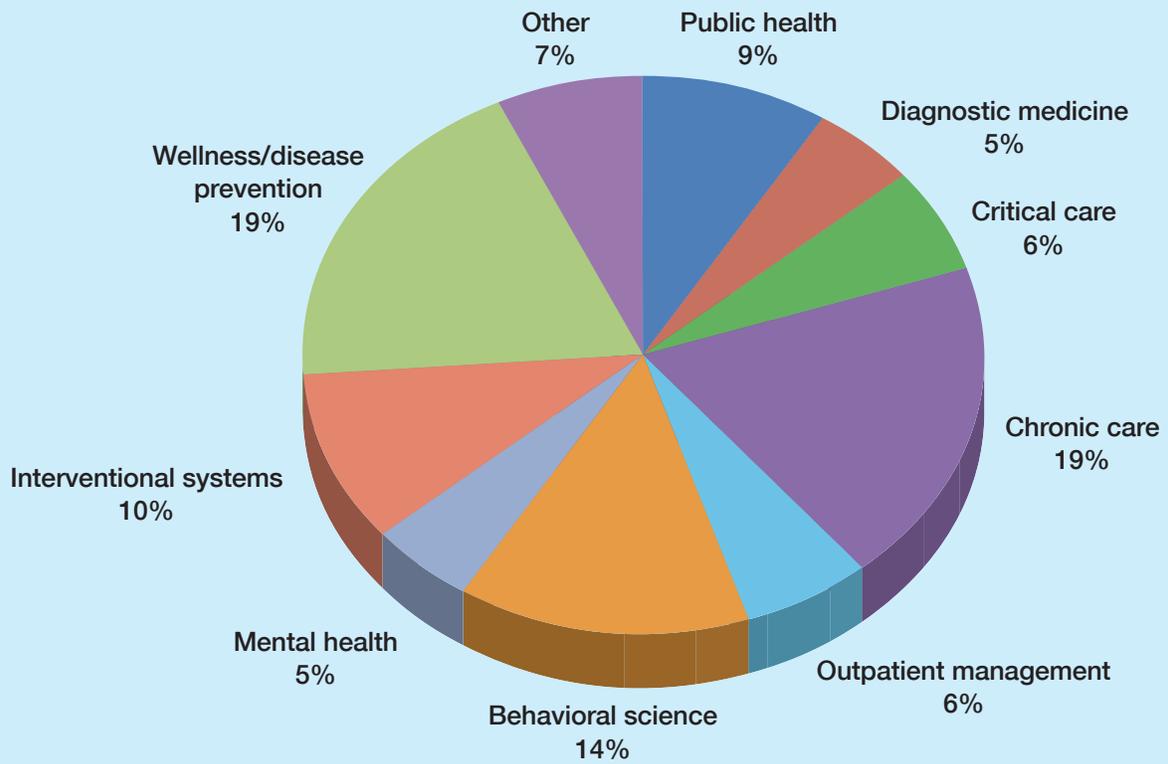
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# APPENDIX A

## Health IT Attendees:

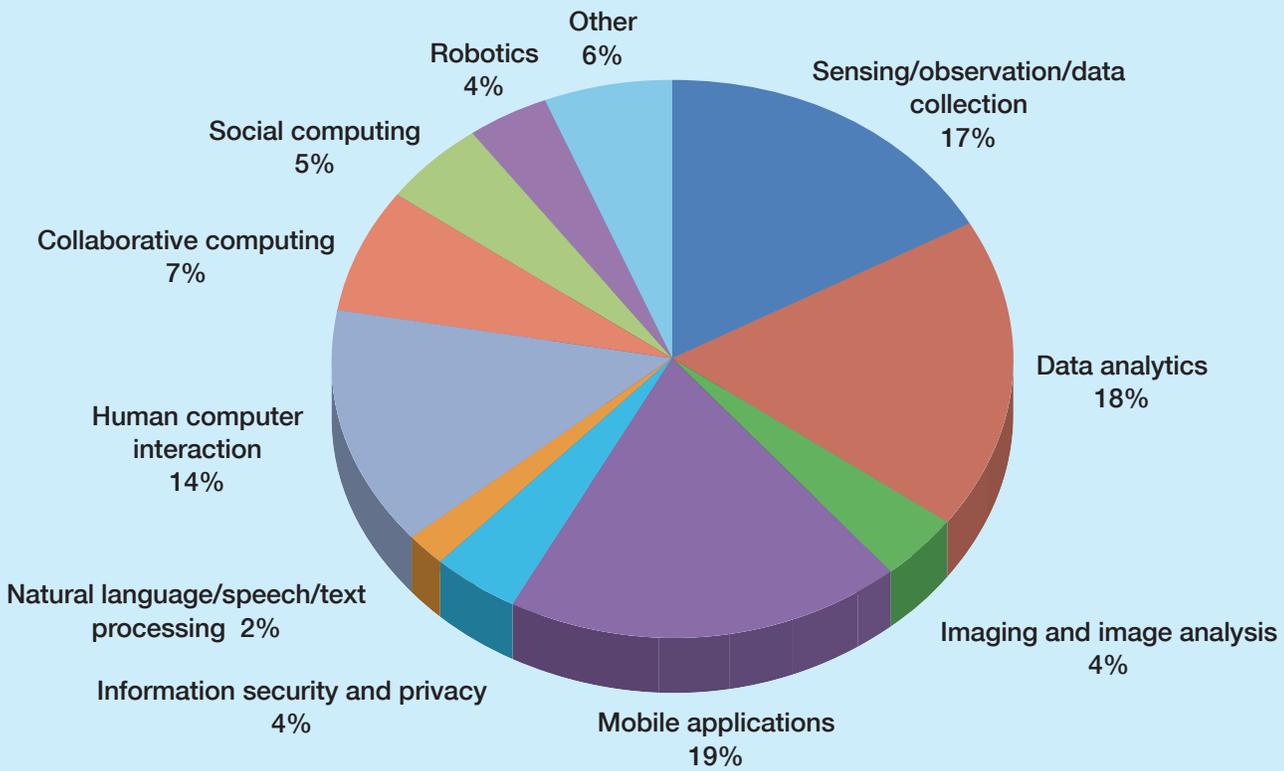
Top two health related topics of interest





### Health IT Attendees:

Top two technology topics of interest





## THE COMPUTING COMMUNITY CONSORTIUM

Established in 2006 through a Cooperative Agreement between the National Science Foundation (NSF) and the Computing Research Association (CRA), the CCC serves as a catalyst and enabler for the computing research community. Its goals are to unite the community to contribute to shaping the future of the field; provide leadership for the community, encouraging revolutionary, high-impact research; encourage the alignment of computing research with pressing national priorities and national challenges (many of which cross disciplines); give voice to the community, communicating to a broad audience the many ways in which advances in computing will create a brighter future; and grow new leaders for the computing research community.



[www.cra.org/ccc/](http://www.cra.org/ccc/)