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Human-Computer Interaction in Health and Wellness: Research and Publication Opportunities

Special Issue: HCI in Health and Wellness

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Abstract:

In this introduction, we address three distinct aspects of the special issue topic "human-computer interaction (HCI) in health and wellness". First, we assess the trajectory of HCI research in health topics in top HCI journals during the 1995-2012 period. We then contrast this overall publication trajectory with the health sector component of gross domestic product (GDP)—applied as a proxy measure of social need—across seven countries that are top producers of HCI research. Second, we describe how one can use the human-technology innovation framework to understand the range of settings in which HCI research in health topics can be conducted. Grounded in this framework, we propose a structure to categorize health related HCI publication and to identify gaps in this research. Third, we apply the proposed structure to categorize and introduce five papers chosen to represent the special issue topic.

Keywords: Healthcare Research, Longitudinal Research, Publication Trends, Human-Technology Innovation Framework, User Experience.

1 Introduction

Advances in science and engineering produce increasingly sophisticated information technology (IT) products for wide-ranging purposes—from entertainment to running household errands and completing job-related tasks—while simultaneously improving reliability and functionality. Yet, as the IT industry matures, many of these products will tend to become commodities, reflecting Nicholas Carr's famous observation that "IT doesn't matter" (Carr, 2003). In reaction to this trend, competition in the overall IT industry increasingly emphasizes improvements in user experience (Tractinsky & Hassenzahl, 2005; Djamasbi 2014a, 2014b; Djamasbi et al., 2015). Consequently, human-computer interaction (HCI) research is becoming increasingly important in developing IT products and services that can "innovate with user experience" and thereby maintain competitive advantage in the marketplace (Djamasbi, 2014b).

Developing services and products that offer innovative user experiences is a challenging task. By definition, the concept of innovating with user experience goes beyond developing products that merely satisfy users' expectations of technology. Instead, products must provide unexpectedly meaningful and delightful user experiences (Kano, Seraku, Takahasi, & Tsuji, 1984; Djamasbi, 2014b). Ironically, this strategy raises the bar for what users expect from new products. What is considered novel today becomes an expected norm—a standard feature—in the next generation of products (Kano et al., 1984), which creates a never-ending cycle of growing expectations (Djamasbi, 2014b).

This cycle of user demand for innovative products and services is likely to have a major impact on the healthcare industry, which has long been noted as a laggard in IT investment (Hillestad et al., 2005). HCI and user experience issues have tended to be assigned a lower priority than achieving technical functionality in developing health IT, even as user demand for these features continued to build. Wilson, Wang, and Sheetz (2014, p. 342) note, for example, that "Web-savvy patients expect their user experience to be as satisfying with e-health as it is with other e-business services". Recently, however, funding for health-related IT has experienced strong growth, especially in technologies that are directed toward improving patient outcomes and reducing costs (Rock Health, 2014). As a result, we anticipate that a tipping point may have arrived in which increasing user expectations for quality user experiences in health and wellness contexts will be supported by expanding investments in health-related IT, which will creating opportunities for new HCI research focused in these areas.

2 Background

The continuous demand for novel technological products with intuitive designs at affordable prices (e.g., smart phones and apps) highlights the need for expanding the pool of talented user experience practitioners (Djamasbi, 2014b). As a consequence, the HCI profession is experiencing strong growth across industries. This growth is perhaps most notable by the emergence of the chief experience officer (CXO) position that has the responsibility to oversee the overall process of and strategy behind an organization's innovation through experience design (Heath, 2015).

The growing need for user experience expertise in practice is also evident in the growth of the HCI community in the larger community of IS scholars. For example, the Special Interest Group in HCI (SIGHCI) established by the Association of Information Systems (AIS) in 2001 has grown to become the largest special interest group in the AIS community. To address this community's needs, SIGHCI holds yearly tracks, mini-tracks, and workshops at six different conferences. HCI research output also has been positively affected by the growing need for innovative user experiences. Between 2000 to 2008, the ratio of HCI-related publications in IS journals had more than doubled from only 20 percent of papers published in 2000 to 45 percent in 2008 (Zhang, Li, Scialdone, & Carey, 2009). As a consequence of this strong growth, in 2009, SIGHCI launched *Transactions on Human-Computer Interaction* (*THCI*), an AIS journal dedicated to HCI research.

One emerging research area that offers a great deal of opportunity for growth is HCI research related to health and wellness. The role of information systems (IS) in health and wellness has experienced a considerable amount of growth in recent years as rapidly increasing demand for health and wellness products and services has emphasized need for digital exchange of and access to health and wellness information. IS use in the healthcare industry has not only an essential role in improving the quality of healthcare (e.g., by preventing or minimizing medical errors) but also an impact on reducing costs and increasing administrative effectiveness and efficiencies. More importantly, IS can facilitate cost-effective

communication and collaboration between patients and health professionals, and it can empower patients to take an active role in improving their health outcomes by, for example, monitoring health conditions (Agu et al., 2013; Wilson, 2009). In this manner, IS-enabled affordances can support and expand access to affordable healthcare.

Despite the increasingly critical role of IS in health and wellness, health has emerged only recently as an important topic for IS researchers. During the 1985-2003 period studied by Chaisson and Davidson (2004), only 1.2 percent of papers published in mainstream IS journals addressed *any* aspect related to health even though the health sector accounted for up to 14 percent of gross domestic product (GDP) in developed nations at that time. Chaisson and Davidson highlighted an unmet social need for IS research on health topics (we refer to this hereafter as health-IS research) and helped to justify development of mitigation strategies. Under the Association for Information Systems (AIS) umbrella, for example, several new health-IS publication opportunities were created (Wilson & Lankton, 2004), including minitracks at the Americas Conference on Information Systems (AMCIS), the Special Interest Group on Information Technology in Healthcare (SIGHealth), and the information systems and healthcare department at *Communications of the AIS* (Wilson, 2004). As a result, by 2009, the rate at which health-IS papers were being published by IS journals had nearly doubled (Wilson & Tulu, 2010).

The concurrent growth of research interest in HCI and health-IS topics has led to focused publication opportunities where the two areas overlap, including a special section in *Communications of the AIS* on patient-centered e-health (Wilson & Strong, 2014) and this special issue in *THCI* on HCI in health and wellness (we refer to HCI research on health topics hereafter as health-HCI research). Because publication is an important "currency" for scholars, it is valuable for health-HCI researchers to understand publication trends in their topic area to identify potential publication opportunities and to pragmatically evaluate constraints that may limit where they will be able to publish their completed manuscripts. In addition, understanding publication trends can highlight areas where health-HCI research is not meeting social needs, which can potentially prompt efforts toward mitigation as has occurred in the area of health-IS research.

To the best of our knowledge, no research has been conducted that addresses trends in publication of health-HCI research by HCI journals. To inform these issues, we studied health-HCI publication trends across eleven prominent HCI journals.

3 Health-HCI Research Trajectory: Research Method

We conducted our study as a keyword-based literature search and abstract review of peer-reviewed HCI journal papers published from 1995 through 2012. We searched 11 journals: the Microsoft Academic Search index (Academic Search, 2013) identified 10 as "top journals in human-computer interaction". In addition, we included *THCI* to the list of journals that we examined (see Table 1 for the complete list of journals).

We identified online indexes for each of the eleven journals and searched using a set of terms previously applied to identify health-related papers in IS journals (Chaisson & Davidson, 2004; Wilson & Tulu, 2010). We used the phrase "physician OR hospital OR medical OR healthcare OR 'health care'" to search full text of over 10,000 papers published by the journals during the study period.

For each of the papers that this search identified, we reviewed its abstract and coded the paper using the following criteria:

- We coded papers as "health related" if they appeared to be conducted in a healthcare setting or were focused toward some aspect of health or wellness (e.g., exercise, diet, smoking, drug use, medical treatment, health condition), and
- We code papers as "non-health-related" otherwise.

Our subsequent analysis is based on 476 papers that we coded as health-related.

4 Health-HCI Research Trajectory: Results

We aggregated results of the analysis into three-year periods to smooth the underlying variation that occurs in the year-to-year data and, thereby, improve interpretability. Table 1 shows the percentage of health-related papers published by the journals during each period.

4.1 Evaluating Publication Trends among Journals

With this research, we focused on identifying health research publication trends among prominent HCI journals, and we interpret several strong trends from the Table 1 data. The results show an overall rise in percentage of health-HCI papers published over time, with over 60 percent increase occurring between 2007-2009 and 2010-2012 periods. However, substantial variation exists among HCI journals in rates of health-HCI publication throughout the studied period. In the 1995-1997 period, for example, half the journals published no health-HCI papers at all. We can also observe substantial divergence through the 2010-2012 period in which one journal (*Human Factors* at 26.8%) published health-HCI papers at over twelve times the rate of the journal that published the fewest (*Mobile Computing and Communications Review* at 2.1%).

Table 1. Percentage of Health-related Papers Published by HCI Journals (1995-2012)

Journal	1995-1997	1998-2000	2001-2003	2004-2006	2007-2009	2010-2012
ACM Transactions on Computer-Human Interaction	0.0%	0.0%	0.0%	3.3%	1.6%	4.1%
Computer Supported Cooperative Work	0.0%	3.8%	1.4%	2.9%	4.3%	9.0%
Human Factors	8.0%	7.5%	5.9%	18.8%	16.2%	26.8%
Interacting with Computers	3.1%	3.0%	6.4%	5.1%	4.8%	13.4%
Interactions	1.3%	0.9%	0.4%	0.4%	4.4%	6.2%
International Journal of Human-Computer Interaction	0.0%	2.9%	4.6%	2.3%	3.8%	7.8%
International Journal of Human-Computer Studies	2.3%	3.3%	1.5%	2.3%	8.3%	5.9%
Journal of Visual Languages and Computing	0.0%	0.0%	1.2%	1.1%	0.0%	2.8%
Mobile Computing and Communications Review	0.0%	1.8%	4.1%	2.7%	2.6%	2.1%
*Transactions on Human-Computer Interaction**					0.0%	7.5%
User Modeling and User-Adapted Interaction	4.0%	0.0%	0.0%	0.0%	1.9%	10.7%
Note: * began publishing in 2009						

We also note a tendency for journals with the highest and lowest health publication rates to retain their positions consistently across the studied period. *Human Factors,* for example, published a higher rate of health-HCI papers than any other journal in all but one of the six periods, whereas *Journal of Visual Languages and Computing* consistently published among the fewest health papers.

4.2 Evaluating Social Need for Health-HCI Research

Our discussion above about health-HCI publication trends provides insights into the *relative* performance of health-HCI publication; that is, how publication rates changed over time and how HCI journals performed relative to one another. We believe it also is helpful to understand publication rates in *absolute* terms, which we conceptualize as HCI journals' responsiveness to social need.

Wilson and Tulu (2010) suggest one method for assessing social need. They report that, in 2009, the rates at which mainstream IS journals published health-IS research continued to lag behind the U.S. health-sector GDP, which accounted in 2015 for approximately 18 percent of overall U.S. GDP. Conceptually, GDP is the total value that a national economy adds annually and is often calculated as gross output less intermediate inputs (Landefeld, Seskin, & Fraumeni, 2008). The amount of overall GDP that is associated with the health sector represents the economic value that each nation allocates to the health of its citizens. Although health-sector GDP is a necessarily coarse measure, we propose it can be a useful proxy of social need for health-related products and services, including health-related research. Applying health-sector GDP as a proxy measure for social need offers several practical benefits, such as:

- Recent GDP data are available for almost all nations.
- GDP inherently incorporates financial trends over time, including productivity growth, inflation, and currency revaluations that may vary substantial among the various national economies.
- Health-sector GDP data encompasses changing healthcare capabilities, including new technologies, pharmaceuticals, and treatments.

Figure 1 graphs the overall publication rate of health-HCI papers by HCI journals against the health-sector GDP (World Bank, 2015) of seven countries that lead in producing HCI research. We took this approach because we anticipate that researchers' choice of research topics is likely to be motivated by social need they perceive in their country of residence.

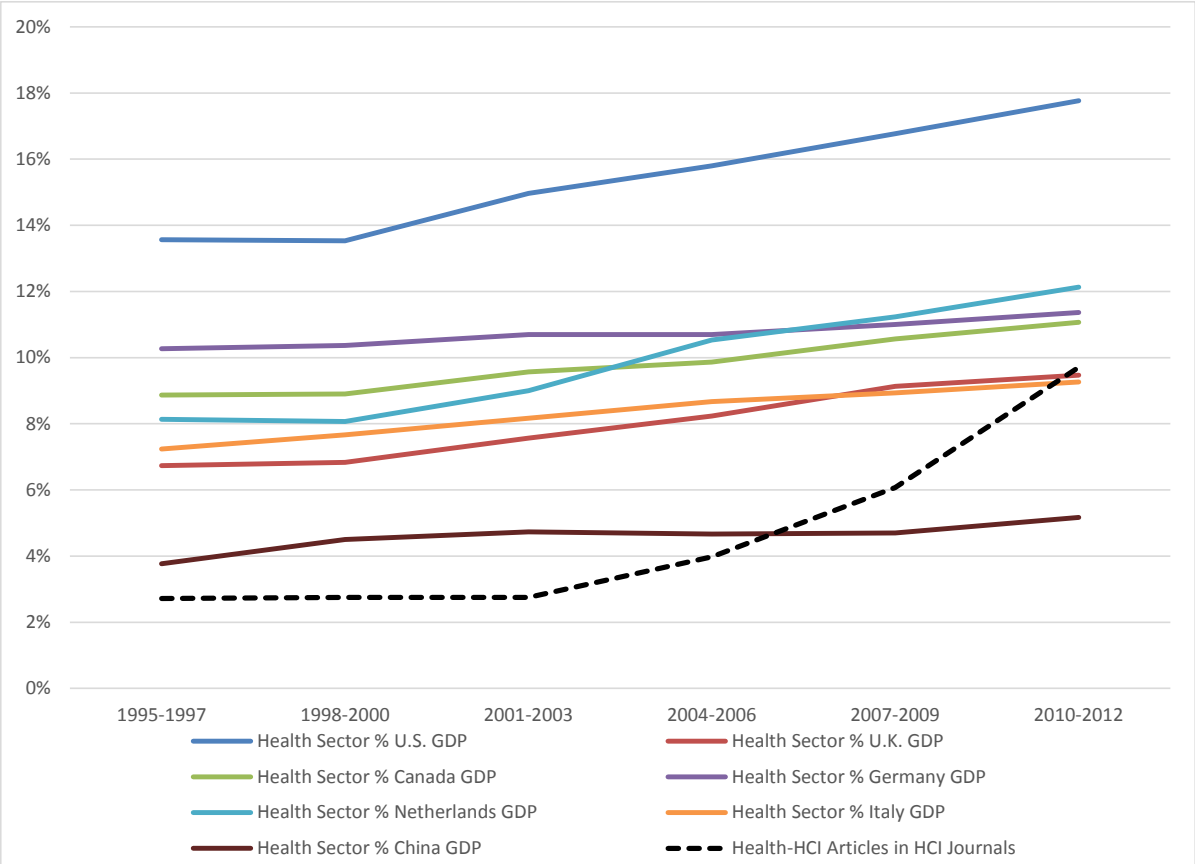

Figure 1. Publication Rate of Health-HCI Papers vs Health-sector GDP, 1995-2012

We drew from two sources to identify countries that lead in HCI research production (see Table 2). Kumar (2013) apply a keyword search using the Web of Science database to determine the HCI publication output by country during the 1987-2011 time period as identified by the residence country reported by each author. Coursaris and Bontis (2012) analyze authorship by residence country in three representative HCI journals from their inception through mid-2010. They use a scoring approach where each co-author on a given papers receives equal credit equivalent to 1 divided by the total number of authors.

We chose to include the top five countries from each study to provide a representative range of GDP statistics that would be relevant to the major sources of HCI research and, at the same time, not be visually overwhelming. Because of the distinct analytical methods Kumar (2013) and Coursaris and Bontis (2012) apply, they produce somewhat different output lists. The top five countries on both lists include US, UK, and Germany; however, China, Italy, Canada, and Netherlands appear in only one of the lists.

Table 2. HCI Paper Publication Productivity By Country

Rank	Kumar (2013)		Coursaris & Bontis (2012)	
	Country	Total Papers	Country	Total Points
1	USA*	45,233	USA*	1059
2	China*	14,101	UK*	540
3	UK*	13,780	Canada*	128
4	Germany*	10861	Germany*	110
5	Italy*	7937	Netherlands*	99
6	France	7839	Japan	77
7	Japan	7732	France	72
8	Canada	7511	Australia	72
9	Spain	7226	Sweden	64
10	Taiwan	7020	Taiwan	50
Note: * included in analysis				

Table 2 suggests that health-sector GDP among the seven profiled nations shown in Figure 1 falls into three general groupings. U.S. health-sector GDP is substantially higher than any other nation throughout the study period: it exceeds the second-highest country by 30 to 50 percent across the six measurement periods. China's health-sector GDP, on the other hand, is at least 34 percent lower than the next lowest country across the measurement periods. The health sector proportion of overall Chinese GDP has grown only slightly since 1995, an effect which is likely due to the Chinese economy's significant expansion during this period. The four European nations and Canada form a grouping at approximately the midpoint between USA and China. These countries' health-sector GDP varies no more than 34 percent from highest to lowest in each of the measurement periods.

Figure 1 illustrates that rates of both health-sector GDP and health-HCI publication have grown overall since 1995, which is not surprising given increased capabilities that the health sector has developed and the increased demand for healthcare services due to the rise in average citizen age and longevity that have occurred during this period. Prior to 2007, health-HCI research was published at a rate lower than the health-sector GDP of any of the seven nations we observe. During the 1995-2003 period, for example, health-HCI accounted for less than 2.8 percent of papers that the HCI journals published, a figure not far removed from 1.2 percent that Chaisson and Davidson (2004) report for health papers published in mainstream IS journals during that period.

Yet, since 2003, health-HCI publication rates have experienced substantial growth. The health-HCI publication rates have increased from 3 to nearly 10 percent from 2003 to 2012. The strong upward trend of health-HCI publications during this period reflects the growth of health-sector GDP across countries that lead in HCI research production and demonstrates that social need for health-HCI is being increasingly addressed by the major HCI publication outlets

The US is an obvious outlier both in health-sector GDP and in production of HCI research. Kumar (2013) found that U.S. researchers produced over 27 percent of the HCI papers published during the 2010-2012 period, an amount greater than the combined production of the three next-highest countries (China, the UK, and Germany, which collectively produced 24 percent of the HCI papers published during 2010-2012). Our findings suggest that a substantial gap remains between health-HCI publication rates of most HCI journals (*Human Factors* being the notable exception) and the level of social need that the United States' health-sector GDP suggests.

5 Health-HCI Research Trajectory: Discussion

Recent trends have resulted in a large increase of health research being published by HCI journals overall, and even journals that published few health-HCI studies prior to 2007 generally have increased their coverage in this area. This is a positive trend for health-HCI researchers, who may have felt in the past that these journals did not welcome their work.

While we recognize that health-sector percentage of GDP is a relatively coarse-grained proxy for social need for health products and services, our findings contrasting health-HCI publication rates with health-sector GDP values show a promising trajectory for meeting social need of the countries we studied. Note, however, that the widest remaining gap between health-HCI publication rates and the level of social need is found in the US, the largest producer of health-HCI research with the largest health-sector GDP.

In total, our findings present good news for health-HCI researchers. We see no reason for the trend slope in health-HCI publication rates to turn downward in the near future because we expect social need for this research will continue to increase to accompany development of advanced e-health systems and other forms of health-IS combined with greater need for health services by aging populations in developed nations.

6 Application of the Human-Technology Innovation Framework

As the quantity of health-HCI publications continues to grow, we anticipate that it will be helpful to examine trends in subcategories in the overall topic area. In this section, we provide an example by applying the human-technology innovation framework (Djamasbi, 2014b) to identify categorical distinctions in health-HCI research.

Innovation means a novel match between an existing or emerging need and a solution. The novelty, which is essential and implicit in innovation, relates to the need, to the solution, or to the way the need and the solution are matched (Terwiesch & Ulrich, 2009; Estrin 2009). We can visualize the design space for novel technological products via the human-technology innovation framework (Djamasbi, 2014b). This framework defines three major axis: user (the human using the technology), technology (the technology that is used), and environment (the environment and/or conditions under which a technology is used). Each axis is further defined with a set of attributes. For example, the attributes for the user axis can include individual characteristics such as age, gender, culture, preferences, attitudes and emotions, expertise, needs, goals, and so on. The attributes for the technology axis can include type (e.g., specificity of purpose), physical attributes (e.g., size, shape, etc.), access/interaction type (touch/gesture, voice, etc.) functionality, features, affordances, and so on. The attributes for the environmental axis comprise all conditions external to the user and the technology, including the setting and/or the physical environment and the task. The combination of the attributes and the interaction among the attributes on each axis provides a vast number of opportunities for designing novel matches between user needs and technological solutions that can provide delightful and effective user experiences (Djamasbi, 2014b).

By defining the technology design space, the human-technology innovation framework provides a structure for understanding the various domains of health-HCI research and identifying gaps in this research. Figure 2 demonstrates how the framework can be applied as a 2 x 2 x 2 matrix where users are distinguished by their use focus (healthcare professionals vs. patients and caregivers), technologies are distinguished by specialization of purpose (general-purpose IT vs. special-purpose health IT), and environment is distinguished by the context of use in clinical vs. nonclinical settings. The resulting octants denoted by letters A through H in Figure 2 describe discrete research settings within the overall health-HCI domain.

7 Papers in the Special Issue

This *THCI* special issue features five papers that exemplify current research in health-HCI. In this section, we briefly introduce each paper and categorize its location in the human-technology innovation framework in Figure 2.

The first paper, “Exploring User Acceptance of a Text-message based Health Intervention among Young African Americans” (Carter, Corneille, Hall-Byers, Clark, & Younge, 2015), focuses on health-HCI from undergraduate students’ point of view. This paper examines the acceptance of a general purpose personal IT for receiving sexual health information via text messaging. Characteristics of patient users, general-purpose IT, and a nonclinical environment place this paper in octant G (see Figure 2).

The second paper, “Examining the Persuasive Potential of Web-based Health Behavior Change Support Systems” (Lehto & Oinas-Kukkonen, 2015), provides an expert evaluation of twelve personal Web-based health systems supporting behavior change in the areas of weight loss and excessive alcohol consumption. Characteristics of patient users, special-purpose health IT, and nonclinical environment place this paper in octant H.

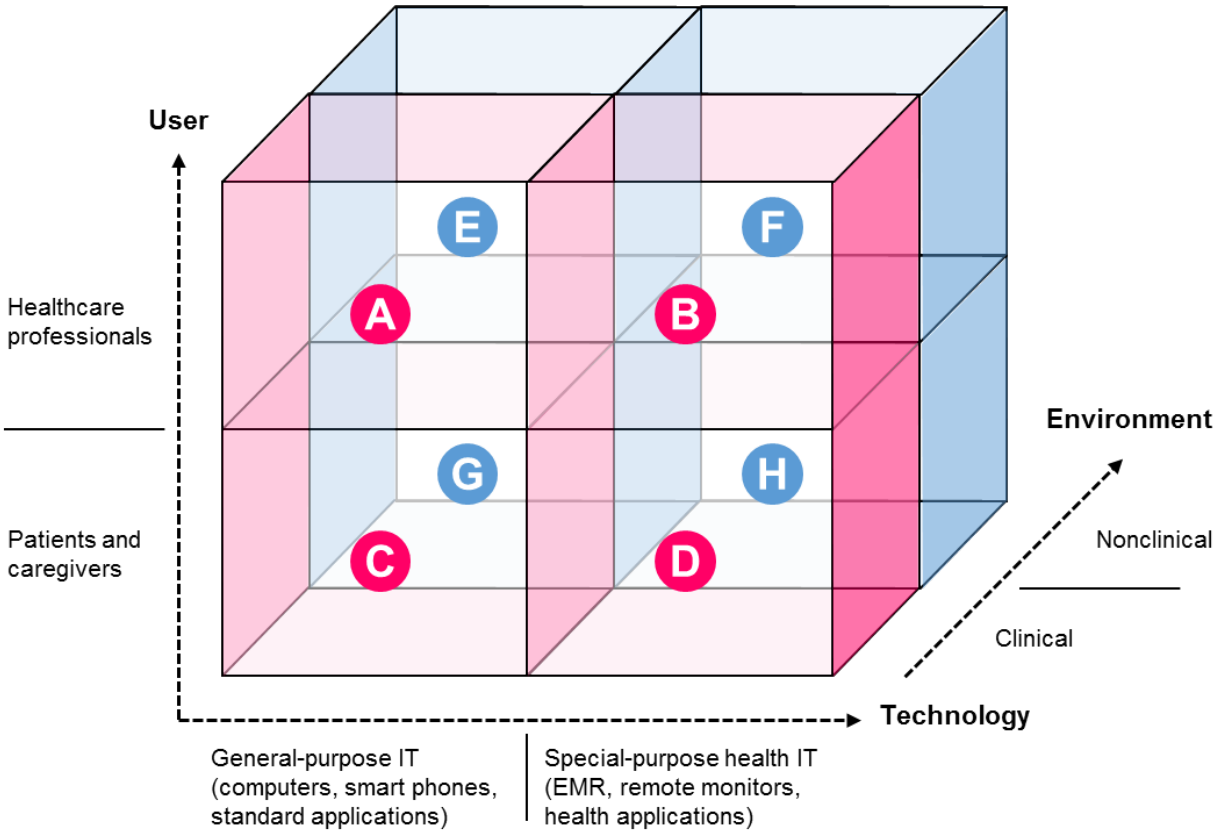

Figure 2. Application of the Human-technology Innovation Framework to Health-HCI Research

The third paper, "Exploring the Role of Contextual Integrity in Electronic Medical Record (EMR) System Workaround Decisions: An Information Security and Privacy Perspective" (Burns, Young, Roberts, Courtney, & Ellis, 2015), examines HCI issues from the point of view of health professionals. The results indicate that contextual integrity is likely to serve as a useful conceptual framework for designing efficient and effective special purpose systems that healthcare professionals use in clinical settings. Characteristics of healthcare professional users, special-purpose health IT, and a clinical environment place this paper in octant B.

The fourth paper, "Understanding Task-Performance Chain Feed-Forward and Feedback Relationships in eHealth" (Chaisson, Kelley, & Downey, 2015), uses a longitudinal study to provide insight for designing effective general purpose personal systems for patients with chronic health issues. Characteristics of patient users, special-purpose health IT, and nonclinical environment place this paper in octant H.

The fifth paper, "Treating Depression through a Behavior Change Support System without Face-to-Face Therapy" (Kuonanoja, Langrial, Lappalainen, Lappalainen, & Oinas-Kukkonen, 2015), examines the impact of two important persuasive features (reminders and rehearsals) of a Web-based behavior change support system for patients that suffer from mild to moderate depression. Characteristics of patient users, special-purpose health IT, and nonclinical environment place this paper in octant H.

In overview, the special issue papers focus on patients, special-purpose health IT, and nonclinical settings. This focus seems appropriate because these characteristics—especially the use of IT by patients in nonclinical settings—represent a major transition accompanying increasing "patient-centeredness" that is emerging in health IT (Wilson & Strong, 2014). We also note reasonable diversity of the papers across the octants, which suggests that our application of the human-technology innovation framework to health-HCI research provides a useful method of categorization.

Octants that the special issue papers do not represent (i.e., A, C, D, E, and F) also represent interesting research questions. For example, octants E and F—describing use of general or special purpose IT in non-clinical settings by healthcare professionals—include such research topics as improving health-HCI

for early responders, such as emergency medical technicians and paramedics. The human-technology innovation framework can also be used for categorizing research that crosses boundaries between octants; for example, research that contrasts the user experience of patients using special-purpose health IT between clinical (inpatient) and nonclinical (outpatient) settings (i.e., octants D and H) or by research that jointly studies the HCI issues a particular health IT poses to healthcare professionals and patients/caregivers (e.g., encompassing octants B and D).

8 Conclusion

Creating this *THCI* special issue has brought special meaning to the adage "the journey is the destination". Following an invitation by *THCI*'s Editors-in-Chief, the HCI in health and wellness project was launched in August 2013 as a collaboration between AIS SIGHealth and SIGHCI. It included a research workshop at AMCIS 2014 in Savannah (where nine manuscripts were invited), and further manuscript recruitment and development continued into spring 2015. Over 50 volunteers from the two SIGS worked as reviewers and workshop discussion moderators in developing this final product. As guest editors, we are satisfied with the results, but, more than that, we are especially pleased with the interactions and experiences we gained in bringing the SIGHealth and SIGHCI communities together to achieve this mutual objective. We sincerely thank all who participated in this project.

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