UNDERSTANDING THE DRIVERS AND CONSEQUENCES OF INTERACTIVE INNOVATION ADOPTION IN HEALTH AND MEDICINE

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ABSTRACT

Providing technologies and services to enable collaboration and communication is a vital concern for information scientists and organizational leaders supporting communities of professionals in research-intensive health care environments. Innovative information practices and technologies—which may include mobile and social-media based technologies, new electronic records systems, new data management practices, and new communication procedures—are developed and introduced, often at considerable cost, with the goal of supporting and enhancing information sharing. However, at times these innovations fail to be adopted by their intended user communities, or adoption leads to unforeseen negative consequences for information sharing within the social environment. The health care sector in particular, while often characterized as generally innovative, has at times been slow to adopt new information innovations. This is a seeming paradox for innovation adoption studies, in which innovativeness is typically treated as synonymous with being among the first to adopt an innovation. This research was conducted in order to better understand the factors that influence or impede interactive innovation adoption in research-intensive health care environments. A four quadrant model, the Pollock Model of Interactive Innovation Adoption (PMIIA) was created and tested in a study of innovation adoption among physicians in training at an academic medical center in the southern United States. Factors from all four quadrants of the model were found to be related to either adoption decisions or perceptions of innovations. Additionally, both personal and

professional values were found to play a role in participants' adoption and use of the innovations.

TABLE OF CONTENTS

Chapter One Introduction and General Information 1
Diffusion of Innovations 2
Interactive Innovations 4
Innovation Adoption in Research-Intensive Organizations 5
Innovation Adoption by Health Care Professionals: Examining the Factors that Influence Adoption 6
Research Goals and Questions 11
Chapter Two Literature Review 14
Diffusion and Adoption of Interactive Innovations 14
Innovation Factors in Diffusion 20
Individual Factors in Diffusion 23
Social and Environmental Factors in Diffusion 27
Use-Related Factors 31
Sociotechnical Approaches to Studying Diffusion and Adoption 35
Sociotechnical Research and the Diffusion of Innovations 35
Values in the Diffusion of Interactive Innovations 40
The Diffusion of Interactive Innovations in Research-Intensive Environments 44
Interactive Innovation Adoption in Health and Medicine: Specific Considerations for Research 46
Chapter Three Model and Methods 51
The Model 51
Research Environment and Study Population 54
Innovations Under Study 55
PerfectServe 55
I-PASS 57
Introduction of Innovations 58
Phase 1: Interviews 61
Phase 2: Survey 65
Protection of Human Subjects 71
Limitations 73
Chapter Four Results 76
Diffusion and Adoption of PerfectServe and I-PASS: An Overview 76
PerfectServe 76
I-PASS 77
Factors Related to Adoption of Innovations in Research-Intensive Health Care Environments 80
Innovation Factors 80
Ease of Use: "It's Not Difficult to Use, when it Works" 80
Innovation Features: "It's Nice When I Can Get Pictures of Things" 87
Relative Advantage: "I'd Rather Just Make a Phone Call" 89
Trialability: "I Was Told, 'This is PerfectServe. We're Gonna Use It. Have Fun.'" 90
Compatibility: A Significant Factor for I-PASS 91

Individual Factors 96
Age or Generation: "I Think There's Always a Barrier to People Who Are Older" .. 96
Gender: Differences in Assessment, Not Adoption 98
Program or Specialty: Differences in Adoption, Not Assessment 101
Personal Innovativeness: Innovativeness, Awareness, and Impact 104
Personal Preferences: "Against My Will, But Yes" 109
Prior Experience: "They Actually Taught Us About…Why Are We Doing This" ... 109
Social and Environmental Factors 111
Internal Factors: "[It's] Not Necessarily Related to PerfectServe, But More Related to Our Culture at the Hospital" 112
External Factors: "[I]t's HIPAA-Compliant for Us to Use It" 125
Use-Related Factors 129
Adaptability of Innovations to Context: "Probably Most Things Could Be Adapted" 129
Overall Impact: "I Don't Like to Use the Word Secretarial" 133
Specific Use Contexts and the Case of Sterile Procedures: "You Have to Let Somebody Unlock Your Phone" 142
Voluntariness of Use: "I Don't Have to Like It" 144
The Role of Values in Innovation Adoption 149
Patient Health, Patient Safety, Patient Lives 149
Privacy: "I've Been a Patient…and Privacy's Important" 151
Security: "It's Great Because It's Secure Communication" 152
Time: "It's Hard Because There's So Much Information...And Not a Lot of Time" 156
Work/Life Balance: "[E]veryone Can Reach You All the Time" 159
Interaction Between Quadrants 160
Chapter Five Discussion and Conclusions 162
Diffusion of PerfectServe and I-PASS 162
Revisiting the Pollock Model of Interactive Innovation Adoption (PMIIA) 163
Innovation Factors: Understanding and Overcoming the High Costs of Use 163
Individual Factors: Different Users, Differing Assessments 168
Social and Environmental Factors: The Need for New Norms 171
Use-Related Factors: The Importance of Considering Contexts 175
The PMIIA as a Whole 178
Values in Diffusion 179
Recommendations for Future Areas of Research and Future Innovation Deployments 183
Innovation Introduction 183
Adaption and Reinvention of Innovations 184
Identification of Innovative Individuals 185
Visibility of Support and Feedback Structures 185
Social Norms and Decision-Making 185
Customization and Voluntariness of Use 186
Interactions Between Contexts and Quadrants 187
Professional Values 187

Personal Values 188
Sources and Resolutions of Value Conflict and Structures of Power 188
Recommendations for Future Research Methods 188
Phase Three: Follow-Up Interviews 188
Going Beyond Self-Report: Ethnographic Observations and Other Alternatives to Surveys 189
Social Network Analysis 190
Models for Predicting Diffusion 191
Testing the Model with New Innovations, New Populations, and New Environments 192
List of References 193
Appendices 226
Appendix A: Phase 1 Interview Guide 227
Appendix B: Innovation Adoption Survey 229
Appendix C: List of Abbreviations 259
Appendix D: Glossary of Terms 260
Vita 263

LIST OF TABLES

Table 1. Phase 1 study participants by specialty. 63
Table 2. Reported specialties of survey respondents. 69
Table 3. Responses by program year. 70
Table 4. Participants' reported gender. 72
Table 5. Assessments of ease of use for PerfectServe. 83
Table 6. Assessment of ease of use for I-PASS. 86
Table 7. Assessments of trialability of PerfectServe. 92
Table 8. Assessments of trialability of I-PASS. 93
Table 9. Assessments of compatibility for PerfectServe. 94
Table 10. Assessments of compatibility for I-PASS. 95
Table 11. Differences by gender in assessments of PerfectServe. 99
Table 12. Differences by gender in assessments of I-PASS. 100
Table 13. PerfectServe use by program. 102
Table 14. I-PASS use by program. 103
Table 15. Thinking about your technology use at work and in everyday life, please rate your level of agreement with the following. 105
Table 16. Assessments of PerfectServe positively correlated with assessments of personal innovativeness. 107
Table 17. Assessments of I-PASS positively correlated with assessments of personal innovativeness. 108
Table 18. Assessments of internal and external use of PerfectServe. 113
Table 19. Assessments of internal use of I-PASS. 114
Table 20. Awareness of internal policies regarding PerfectServe. 115
Table 21. Compatibility of PerfectServe with internal policies. 116
Table 22. Awareness of Internal policies regarding I-PASS. 117
Table 23. Assessments of availability of support for PerfectServe. 122
Table 24. Assessments of availability of support for I-PASS. 124
Table 25. Assessments of external use of PerfectServe. 126
Table 26. Assessments of external use of I-PASS. 127
Table 27. Assessments of adaptability of PerfectServe. 131
Table 28. Assessments of adaptability of I-PASS. 132
Table 29. Assessments of impact of PerfectServe on own work and communication. 135
Table 30. Assessments of impact of PerfectServe on work and communication within the organization. 136
Table 31. Assessments of impact of I-PASS on own work and communication. 139
Table 32. Assessments of impact of I-PASS on work and communication within the organization. 140
Table 33. Assessments of voluntariness of use for PerfectServe. 146
Table 34. Assessments of full adoption for PerfectServe. 147
Table 35. Assessments of voluntariness of use for I-PASS. 148

Table 36. Assessments of security and privacy of information shared via PerfectServe. 154
Table 37. Assessments of security and privacy of information shared via I-PASS..... 155

LIST OF FIGURES

Figure 1. The Pollock Model of Interactive Innovation Adoption..... 52
Figure 2. Have you ever heard about PerfectServe?..... 76
Figure 3. Do you currently use PerfectServe?..... 77
Figure 4. Have you ever heard about I-PASS? 78
Figure 5. Do you currently use the I-PASS handoff procedure?..... 79
Figure 6. The Pollock Model of Interactive Innovation Adoption (PMIIA) revised. 81

CHAPTER ONE
INTRODUCTION AND GENERAL INFORMATION

Providing technologies and services to enable collaboration and communication is a vital concern for information scientists and organizational leaders supporting communities of professionals in research-intensive health care environments. Innovative information practices and technologies—which may include mobile and social-media based technologies, new electronic records systems, new data management practices, and new communication procedures—are developed and introduced, often at considerable cost, with the goal of supporting and enhancing information sharing. However, at times these innovations fail to be adopted by their intended user communities, or adoption leads to unforeseen negative consequences for information sharing within the social environment. Studies have estimated the failure rate of new information and communication technology (ICT) projects is around 50% to 80%, with at least part of this rate attributed to failure of the innovation to be successfully adopted within a social system after deployment (Day & Norris, 2007). The health care sector in particular, while often characterized as generally innovative, has also been found to be one of the slowest to adopt information technology innovations (England, Stewart, & Walker, 2000; Grimson, Grimson, & Hasselbring, 2000; Steinhubl & Topol, 2015; Tsai & Hung, 2016). This is a seeming paradox for innovation adoption studies, in which innovativeness is typically treated as synonymous with being among the first to adopt an innovation (see Rogers, 2003). Often, what makes an innovation successful is context-specific. Not all innovative practices and technologies are

appropriate for all environments or all users, and innovative information technologies and practices that have been successful in other contexts have not always been well-adopted by scientific and medical communities (Greenhalgh, Robert, Bate, Macfarlane, & Kyriakidou, 2005; Greve, 2011; Nentwich & König, 2012).

What influences practitioners in health care environments to adopt innovative technologies and practices for information sharing within the context of their work? What factors represent barriers to adoption? Being able to answer these questions can help avoid a potential waste of resources and inform the development of information tools and technologies that better support communication needs. Tools that would enable organizations to discover and leverage information about new interactive innovations, as well as about their own organizations' personnel, cultures, work processes, communication practices, and values may help leaders and information professional better predict adoption behaviors and patterns of diffusion before incurring the costs of developing and introducing an innovation. Further, these tools might be adapted, not only for use in multiple types of health care organizations, but in other research-intensive environments in science, technology, and medicine.

Diffusion of Innovations

The Diffusion of Innovation theory originated in rural sociology and has since been employed by researchers in multiple disciplines, including health, anthropology, communication, economics, information studies, political science, and other subfields within sociology (Fichman, 1992; Lievrouw, 2006; Rogers, 2003). In his classic work *Diffusion of Innovations*, currently in its fifth edition, M. Everett Rogers (2003) defines

diffusion as "the process in which an innovation is communicated through certain channels over time by members of a social system" (p. 5). This definition encompasses the four main elements identified in the diffusion of innovations, specifically:

1. The *innovation*, "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (p. 12).
2. *Communication channels*. Here, communication is "a process in which participants create and share information with one another in order to reach a mutual understanding" (p. 5), and a communication channel is "the means by which messages get from one individual to another" (p. 36).
3. *Time*, a dimension of, a) the innovation-diffusion process through which a decision-making unit moves from first knowledge of an innovation to confirmation of the decision to adopt or reject it; b) innovativeness, or the degree to which a unit is relatively earlier in adopting innovations than other members of a social system, and, c) the innovation's rate of adoption by members of a social system.
4. *Social system*, or "a set of interrelated units that are engaged in joint problem solving to accomplish a common goal" (p. 23). The structure and norms of a social system, as well as individual adopters' degree of influence on the system can impact diffusion.

Adoption is "the decision to make full use of an innovation as the best course of action available" (Rogers, 1986, p. 122). Patterns and rates of adoption, as well as whether or not diffusion is ultimately successful, are all influenced by the specific

characteristics of innovations, adopters, and the social systems in which diffusion takes place.

Interactive Innovations

Interactive innovations are innovative information practices or technologies meeting Markus's (1987) definition of an interactive medium, or a "vehicle that enables and constrains multidirectional communication flows among the members of a social unit with two or more members" (p. 492).

While classical studies of diffusion have found that diffusion of most innovations follows a similar pattern, with the decisions of later adopters impacted by the decisions of prior adopters (Rogers, 2003), in the case of interactive innovations, the reverse is also true. The value of an interactive technology for an individual user is dependent on *network externalities*, or how many others in a community are using the technology, as well as how they are using it (Katz & Shapiro, 1986).

In the stages where few others are using an interactive innovation there may be little initial benefit for the early adopters, and the costs of adoption, particularly costs of time and energy associated with sending a message via both new and existing communication channels to make sure it reaches all intended recipients, may be quite high (Karsten & Laine, 2007). If others with whom the user communicates do not also eventually adopt the innovation, use is likely to discontinue. This reciprocal interdependence between early and later adopters makes diffusion of interactive innovations complex (Markus, 1987).

Innovation Adoption in Research-Intensive Organizations

Research-intensive organizations are here defined as those for which research and development represent major activities of the organization and the production of new ideas and new innovations, major outputs (see Minguillo, Tijssen, & Thelwall, 2015). Research-intensive organizations tend to be characterized by high levels of research and development (R&D) and intellectual property (IP) assets, such as patents and trademarks (Maldonado & Brooks, 2004), and include university, government, non-profit, and private organizations. Not all research-intensive organizations will have R&D output as a singular or primary focus. A *research-intensive environment* may also characterize a single department or division within a larger organization, such as an R&D department. Other research-intensive environments may have multiple missions. In the field of health and medicine, research-intensive organizations such as academic research and teaching hospitals, are highly service-focused, with patient care a primary activity (Djellal, & Gallouj, 2007; Greenhalgh et al., 2005).

Research-intensive organizations can have a variety of specialties. The literature that informs this research primarily focuses on interactive innovation adoption in those organizations specializing in the scientific and technical fields covered in a 2007 economic report by the National Academies (National Academies, 2007), the research areas funded by the 27 institutes and centers that make up the National Institutes of Health (NIH, n.d.), and the 160 STEM (science, technology, engineering, and mathematics) disciplinary areas defined by the National Science Foundation (NSF, 2015). Professionals within research-intensive organizations are not a monolith; similar

to other social groups, disciplines, professions, and communities of practice, each have their own cultures, norms, research practices, and patterns of communication (Becher, 1991; Borgman, 2007; Cooke & Hilton, 2015). New interactive ICTs, particularly Internet-based tools, have changed scientific communication practices, though perhaps not as rapidly or as drastically as some scholars in the information sciences had previously anticipated (Barjack, 2003; Kling & Callahan, 2003). The values, norms, and communication practices of larger disciplinary and professional communities can influence how and whether information is communicated within and by the members of these communities, to whom it is communicated, and even what information is likely to be considered valid (Becher, 1991; Greenhalgh et al., 2005; Habermas, 1996; Longino, 1990; Rahimi, Timpka, Vimarlund, Uppugunduri, & Svensson, 2009; Reychav & Aguirre-Urreta, 2014).

Innovation Adoption by Health Care Professionals: Examining the Factors that Influence Adoption

A number of studies have looked at the specific factors that influence the diffusion of ICTs and their adoption by various communities of professionals in the fields of health and medicine (see Cain & Mittman, 2002; de Grood et al., 2016; Ward, 2013; Weigel & Hazen, 2013; Weigel, Rainer, Hazen, Cegielski, & Ford, 2012). Many have looked at the characteristics of individual innovations. Five innovation characteristics identified by Rogers (2003) in the original diffusion model—relative advantage, compatibility, complexity, trialability, and observability—have been empirically shown to play an important role in diffusion of innovations in health care settings, though these

concepts are highly context-specific and in certain cases, remain difficult to quantify, particularly an innovation's relative advantage in terms of overall impact on patient outcomes, quality of care, and patient safety (Berwick, 2003; de Groot et al., 2006; Greenhalgh et al., 2005; England et al. 2000).

The characteristics of those individuals capable of making adoption decisions are also important factors. Often, a single interactive innovation is deployed within an organization for use by multiple heterophilous groups, or groups that differ from each other in important ways (Cain & Mittman, 2002). When multiple groups of professionals—such as physicians, nurses, and administrators—all need to access and share information via a single information technology or system, all may have different goals, needs, areas of expertise, and ways of communicating, some of which the innovation may fit better than others (England et al., 2000). In research-intensive environments, an individual's professional identity, disciplinary communication practices, and roles within the workplace can be more important predictors of adoption of interactive innovations than other demographic characteristics; for example, physicians' specialty and organizational roles can influence adoption of information technologies (IT) for work-related activities, but previous studies have found their familiarity with and use of IT in their personal lives is not well correlated with their adoption of IT for professional use (Cain & Mittman, 2002). A knowledge of the individuals within a social environment, and their values, communication needs, and attitudes towards and experiences with innovations can help explain innovation adoption patterns.

Understanding innovation adoption also requires an understanding of those social and environmental factors that influence innovation adoption, including the perceived role of the innovation within the social environment (Ackerman et al., 2012; Greenhalgh et al., 2005). Also important is understanding the social *norms*, or established behavior patterns, that influence communications within a social system. This includes existing communication networks and the place of individuals within those networks, particularly those individuals who function as *opinion leaders* within the network, capable of influencing the attitudes and behaviors of others (Rogers, 2003). Interactive innovations, once adopted, will by definition shape and change the social system of which they become a part, given that they impact the communications that occur within it (Bowker, 2005). Qualitative research approaches can be useful in examining the interactions between social systems and innovations (Van House, 2004). Here, Bruno Latour's (2005) Actor-Network Theory, Jürgen Habermas' (1987) concept of the lifeworld, and the examination of the values that go into innovation design represent useful frames for studying how interactive innovations both impact and are impacted by the social systems in which they are created and introduced.

Within organizations, organizational structures, cultures, and the availability of training and support when needed can profoundly shape individual innovation adoption decisions (England et al., 2010; Michel-Verkerke & Spil, 2013). Formal policies which either encourage or inhibit the use of an innovation are another important factor, especially when information security and information privacy are dominant concerns. In health care, the need to protect the privacy and security of patient information has been

cited as one reason for the relatively slow pace at which the sector tends to adopt new electronic information technologies (Miller & Tucker, 2009).

External social and environmental factors can also impact adoption. For example, many requirements related to information privacy and security are legal requirements from external governing bodies. In the United States, the Health Insurance Portability and Accountability Act (HIPAA) Security Standards for the Protection of Electronic Protected Health Information and Standards for Privacy of Individually Identifiable Health Information from the United States Department of Health and Human Services (n.d.) govern the communication of protected health information that could be used to identify a patient. Such regulations impact how and if information is shared in particular contexts and what methods may be employed to share it. Additionally, in the case of research-intensive environments, disciplinary communication and collaboration norms have been shown to impact information behaviors, including technology adoption behaviors (Cain & Mittman, 2002; Zolla, 1999). An understanding of the constitutive values of what Habermas (1996) termed the empirical-analytic sciences, as well as the types of information and data created and considered valid in the course of practice in a research-intensive community can be essential to understanding patterns of diffusion and the impact of innovations on a research-intensive environment (Longino, 1990; O'Donnell & Henriksen, 2002).

Use-related factors have not typically been considered as a separate category in diffusion research, but to present a full picture adoption of interactive innovations, it is important to understand not only whether or not the innovation has been adopted, but

how the innovation is actually used in the context in which adoption occurs. Research has shown that once interactive innovations are adopted, they often undergo substantial revision and adaptation to better match them to environment and task (Hanseth & Aanestad, 2003). It is also possible that not all features of the innovation are being used, or that the innovation is being used in ways other than those the designers anticipated. For example, while interactive innovations are meant to enable two-way communication, the population of adopters may include those who use them primarily or exclusively for information consumption without contributing information of their own (Reychav & Aguirre-Urreta, 2014; Tenopir, Volentine, & King, 2013). Another important use-related factor in organizational contexts is whether or not adoption is, or is perceived to be, voluntary on the part of individual adopters (Venkatesh, Morris, Davis, and Davis, 2003).

Values are an important component of human decision making. There have been a number of ways of conceptualizing values in the research literature of various scholarly fields (Cheng & Fleischmann, 2010). For the purposes of this research, *value* "refers to what a person or group of people consider important in life" (Friedman, Kahn, & Borning, 2009). Researchers who study values in design examine "individual and social values as equally important inputs to the technology design process" (EVOKE, 2015). In the case of interactive innovations, values play a role in decisions made at the very beginning stages of the design, including those related to how to classify information and present it to users, what standards and specifications to use, and what workflows, and types and patterns of communication the innovation will support (Berg,

2001; Bowker, 2005; Bowker & Star, 2000; Friedman, Kahn, & Boring, 2008; Knobel & Bowker, 2011). Once these decisions are made, these values become an inherent and often invisible part of the innovation, and if it is successfully diffused within a social system, will ultimately play a role in shaping the system itself (Berg, 2001; Bowker, 2005; Lievrouw, 2006). Individual, professional, and cultural values can shape not only an innovation, but also its eventual adoption and use in context (Friedman et al., 2009; Goodman, 2008; Kotter, 2012). If the values and norms inherent in an interactive innovation lack compatibility with the values of its intended users, the innovation may be rejected or require extensive reprogramming before diffusion is achieved (Berg et al., 2003). The concept of values is part of Rogers' (2003) diffusion model; the definition of the innovation characteristic of compatibility includes compatibility with users' existing values. A number of personal and professional values may be in play in research-intensive health care environments, including the high value physicians place on their time, as well as their perceptions of innovations as either being time savers or as taking time away from their work (de Grood et al., 2016; Goodman, 2008).

Research Goals and Questions

This research contributes to the literature on diffusion by focusing on the specific factors related to interactive innovations and the specific factors that impact work-related communication behaviors, and potentially the diffusion of these innovations, among professionals in research-intensive health care environments. The ultimate goal of this research is for it to have practical applications, and for the tools developed in the research process to help enable information professionals and organizational leaders to

better understand their own environments and potentially predict adoption behaviors prior to developing and introducing an innovation.

Chapter Two provides an in-depth review of the literature related to interactive innovation adoption in research-intensive health care environments. Chapter Three describes a model identifying four broad categories of factors that potentially influence adoption behaviors and rate of diffusion of innovations in research-intensive environments, which include factors related to:

- the innovation itself
- the individuals capable of making a decision to adopt the innovation,
- the internal and external social and environmental contexts of adoption, and
- the actual uses of the innovation in context.

This section also goes on to detail the two-phase mixed method research approach used to test the model in a study of adoption by physicians in training at an academic medical center. Chapter Four presents study results. In Chapter 5, results and conclusions are discussed and suggestions are made for future research.

The research questions motivating the study are as follows:

- **RQ1:** What factors influence adoption of innovations for information sharing and communication in research-intensive health care environments?
- **RQ2:** Which factors have the most impact on the probability of adoption of an interactive innovation by target users?
- **RQ3:** Do personal and professional values impact innovation adoption in research-intensive health care environments? If so, what values are in play?

- **RQ4:** Are there other factors important to interactive innovation adoption in research-intensive health care environments that are not included in the research model?

CHAPTER TWO
LITERATURE REVIEW

The first part of this literature review presents a broad overview of diffusion of innovation theory and the issues related to the diffusion of interactive innovations in particular, including the concepts of reciprocal interdependence and network externalities. It then discusses the factors found to impact adoption and diffusion in prior research, including those related to the innovation, individual adopters, the social and environmental contexts of adoption, and actual uses of the innovation in context. The second part examines sociotechnical approaches to studying innovation adoption, looking at the role of interactive information technologies in social systems, and the role personal and professional values may play in innovation adoption decisions. The final part takes an in-depth look at examples of interactive innovation diffusion in research-intensive environments and the specific factors that may prove of importance when studying interactive innovation adoption in the health and medical sector in particular.

Diffusion and Adoption of Interactive Innovations

Diffusion is defined as "the process in which an innovation is communicated through certain channels over time by members of a social system" (Rogers, 2003, p. 5). In the diffusion of innovations model, an innovation may be a particular object or type of technology, or it may be an idea or practice. Some innovations may involve the adoption of new ideas, new technologies, and new information practices simultaneously, as part of a package, or in rapid succession, as part of a substantial shift in communication, work, or research practice; examples include the diffusion of

evidence-based medicine or the diffusion of data-intensive scientific research (Greenhalgh et al., 2005; Hey, Tansley, & Tolle, 2009). Classical studies of diffusion of innovations have found that, while rates of adoption vary, diffusion typically, though not always, tends to follow a normal, bell-shaped curve when plotted over time, or an S-shaped curve if plotted by the cumulative number of adopters (Rogers, 2003).

Adoption, again, is "the decision to make full use of an innovation as the best course of action available" (Rogers, 1986, p. 122). Rogers (2003) conceptualized a five-stage process from which the individual moves from initial knowledge of the innovation to eventual confirmation of the decision to adopt or reject it and describes these stages as follows:

1. *Knowledge:* When a decision-maker "learns of the innovation's existence and gains some understanding of how it functions" (p. 20),
2. *Persuasion:* When the decision-maker "forms a favorable or unfavorable attitude toward the innovation" (p. 20),
3. *Decision:* When the decision-maker chooses to adopt or reject the innovation,
4. *Implementation:* When the innovation is put to use, and
5. *Confirmation:* When reinforcement of the previous decision to adopt or not is sought.

In the final stage, decision-makers who have previously decided to adopt the innovation may opt for continued adoption, or they may decide to discontinue using the innovation. Those who have initially chosen to reject the innovation may likewise opt for continued rejection or may decide to adopt at this later stage. In this phase, the

importance of network externalities and the reciprocal interdependence of early and later adopters of interactive innovations comes into play, as early adopters are likely to cease using an innovation if not enough others have adopted it in the meantime to make its continued use advantageous (Markus, 1987).

Markus (1987) considered the specific issues surrounding the diffusion of interactive media, with an interactive medium defined as a "vehicle that enables and constrains multidirectional communication flows among the members of a social unit with two or more members: Examples are telephone, paper mail, electronic mail, voice messaging, and computer conferencing." This definition also covers newer interactive technologies examined in diffusion studies, including electronic health records, the Internet and intranets, social networking services, web-based information sharing systems, wikis, telemedicine systems, and other electronic communication technologies (Daim, Tarman, & Basoglu, 2008; Greenhalgh et al., 2005; Hester, 2011; Kerleau & Pelletier-Fleury, 2002; Lievrouw, 2006; Miranda, Kim, & Summers, 2015; Wang, Jung, Kang, & Chung, 2014; Wu & Wu, 2012).

Traditional diffusion studies rely on models of contagion where later adopters are assumed to be influenced by the behavior of earlier adopters and make the decision to adopt an innovation once a "threshold" number of others within a community or network already engaged in adoption behavior has been reached (Granovetter & Soong, 1983; Monge & Contractor, 2001; Rogers, 2003; Schelling, 2006; Valente, 1995; Zheng, Padman, & Johnson, 2007). While the influence of prior adopters on the behavior of later adopters is also found in the case of interactive media, Markus (1987) notes that

with these technologies, influence is reciprocal rather than sequential; the behavior of early adopters is also dependent on the behavior of later adopters (Markus, 1987).

In the case of an interactive medium, its value for an individual user is dependent on network externalities, or the number of others in the community also using the medium. Katz & Shapiro (1985) identify two types of network externalities: direct and indirect. The telephone is one example of an innovation with direct network externalities; for this technology to be used for its intended purpose, others with whom the user wishes to communicate must also have adopted it. The VCR is an example of a then-current technology with indirect externalities; here, a single user could make use of the technology for its intended purpose without relying on reciprocal adoption behaviors from others, but the value of the innovation is increased by the amount of compatible content of interest produced for it, which increases as more VCRs are sold (Katz & Shapiro, 1986). While most studies of network externalities focus on technical innovations, the same considerations will apply to innovations that are information processes, if in any way the value of these processes is also dependent on their use by others.

Current interactive ICTs such as EMRs, the Internet, mobile apps, or social media-based tools may have both direct and indirect network externalities; the innovation's value to a particular user may not only depend on how many others are using the innovation, but also on who is using it, how it is being used, and whether or not the information being produced and shared via the innovation represents information of value to the potential adopter (Bowker, 2005; Karsten & Laine, 2007;

Markus & Connolly, 1990; Nentwich & König, 2012; Rice, Grant, Schmitz, & Torobin, 1990). In the early stages of diffusion, when little content is being produced and shared by anyone within a social system, the value of the innovation to early adopters is likely to be low and its potential future value unclear. Further, early adopters are likely to initially incur increased costs as a result of their decision to adopt the innovation before it is fully diffused; for example, the costs of time and effort associated with the need to keep duplicate records or convey the same information via multiple systems and channels in order to make sure it is received by all intended recipients (Greiver, Barnsley, Glazier, Moineddin, & Harvey, 2011; Karsten & Laine, 2007; Lievrouw, 2006).

These costs and the impact of network externalities may vary depending on to what extent new innovations are compatible with existing communication tools and systems (Katz & Shapiro, 1986). For example, smartphone users are capable of using these devices to share at least some types of information with landline and mobile phone users, with users of laptop and desktop computers, and with users of other brands and generations of smartphones, even if they are not necessarily able to make use of all possible features of their own devices in these communications. Often, multiple generations of the same technology or compatible technologies are in use within a social system at a given time (Norton & Bass, 1987). In the case of complex communication technologies, Rogers (1986) notes the importance of distinguishing between adoption of an innovation and its full implementation. This will be discussed further in the section of this literature review related to use.

If those with whom an early adopter needs to communicate do not also eventually adopt an interactive innovation, use of it is likely to discontinue at Rogers' confirmation stage (Markus, 1987). As such, the diffusion of interactive innovations is highly dependent on achieving a critical mass of users, who may at first receive little value from the innovation, for later adoption to occur (Markus, 1987; Markus & Connolly, 1990; Rice & Gattiker, 2001). *Critical mass* refers to the minimum number of users required to sustain diffusion (Valente, 1995). Applying Oliver, Marwell, & Teixeira's (1985) theory of critical mass and collective action to interactive media adoption, Markus (1987) posits that a heterogeneity of resources and use of the innovation by high-resource, high-interest individuals within the community (who will presumably share high-value information), along with factors that make the initial costs of adoption lower for individuals, all increase the likelihood of adoption. Once this critical mass is reached, further diffusion within the community becomes self-sustaining and additional intervention becomes unnecessary (Hanseth & Aanestad, 2003). Within larger organizations, critical mass may occur at a more local level or at the level of a subgroup (Rice & Gattiker, 2001; Valente, 1995). Depending on the innovation, subgroup adoption may be sufficient for the innovation to function properly; for example, Weigel and Hazel (2013) note that while it may be essential for patient care for all providers in a hospital to use the electronic medical records system, the same may not be true for the hospital's automated supply chain system.

Many factors may impact the diffusion of a particular innovation in a particular environment, and the relationship between those factors can be complex. In a review of

the literature on innovation, Jeyaraj et al. (2006) identified 135 independent variables, eight dependent variables, and 505 relationships that had been tested in diffusion studies published between 1992-2003. In their literature review on modeling and forecasting diffusion, Meade and Islam (2010) identified thirteen separate S-shaped diffusion models. New models for predicting diffusion, such as the USE IT model for predicting ICT diffusion in health care (Michel-Verkerke & Spil, 2013); the FITT framework which incorporates the variables of interaction between users, technologies, and tasks (Ammenwerth et al., 2006); and the Technology-Organization-Environment (TOE) framework for studying IT adoption at the organizational level (DePietro, Wiarda, & Fleischer, 1990) are being developed and tested constantly. Diffusion research may lead to the identification of new variables to be incorporated into existing models (see Tully, 2015) or to the creation of new models by adapting or combining previous models (see Venkatesh et al., 2003). The next four subsections examine factors related to innovations, individuals, social and environmental contexts, and innovation use that have been studied in prior diffusion research.

Innovation Factors in Diffusion

In *Diffusion of Innovations*, Rogers (2003) lists five perceived characteristics of innovations that determine their rate of adoption:

1. *Relative advantage*, "the degree to which an innovation is perceived as better than the idea it supersedes" (p. 15);

2. *Compatibility*, "the degree to which an innovation is perceived as being consistent with existing values, past experiences, and needs of potential adopters" (p. 15);
3. *Complexity*, "the degree to which an innovation is perceived as difficult to understand and use" (p. 16);
4. *Trialability*, "the degree to which an innovation may be experimented with on a limited basis" (p. 16); and
5. *Observability*, "the degree to which the results of an innovation are visible to others" (p. 16).

Subsequent research has shown that together, these five characteristics explain about 49% to 87% of the variance in innovation adoption rates (Tidd, 2010), though the significance of each factor as a predictor of adoption behaviors may vary by context and by innovation (Greenhalgh et al., 2005). It is important to note that none of these features are inherent features of the innovation itself and measuring them depends on some degree of understanding of their intended users, uses, and/or the social contexts of use. Of these five, complexity is perhaps the easiest to measure prior to the introduction of an innovation in context. Complexity is negatively correlated with innovation adoption and diffusion researchers may instead measure its opposite, ease of use (Moore & Benbasat, 1991). Complexity, or ease of use, might be measured via traditional usability studies (Nielsen, 2012) examining, for example, the ease of use of an ICT's interface design and how quickly users can perform required tasks or find needed information. Additional components of complexity may come into play only

when the innovation is introduced in the particular context of use, for example, if pre-programmed workflows do not match existing workflows in a particular environment, or if information in the system is classified in such a way that it makes it difficult for members of the expected user community to input or find it (Bowker & Star, 2000; Hanseth & Aanestad, 2003). Another dimension of complexity is closely related to the concept of *affordances* in human-computer interaction studies, or the actions it is possible to perform with the innovation and how easy they are for the user to perceive (Kaptelinin, 2014). Even the simplest interactive innovations by definition allow for multidirectional communication and thus multiple actions, and it is possible that users may not fully adopt an innovation for all the communication activities for which it is intended, choosing instead to use it exclusively or primarily for information creation or information consumption (Reychav & Aguirre-Urreta, 2014; Tenopir et al., 2013). Partial adoption of innovations will be discussed in a later section. Relative advantage, compatibility, trialability, and observability are also perceived features of the innovation itself that rely a great deal on the contexts in which the innovation is being introduced and its appropriateness not only for the environmental contexts of use, but also for the specific tasks for which it is employed; to the extent the innovation lacks compatibility with any of these, user perceptions of innovation attributes will be impacted (Moore & Benbasat, 1991).

Researchers have proposed additional attributes beyond these five, such as perceived flexibility, reliability, security, and trustworthiness of the innovation, that may also play roles in adoption decisions (Bandlow, 2015; Jeyaraj, Rottman, & Lacity, 2006;

Tully, 2015; Wang et al., 2014; Wu & Wu, 2012). In health care settings, security of an ICT and its capabilities for the secure communication of confidential patient information are likely to be paramount concerns (Cain & Mittman, 2002; Goodman, 2008; Zolla, 1999).

Here it is important to note another feature of interactive innovations: they are likely to undergo reinvention and restructuring as they are adopted and used by the members of a particular community, and specific features and uses are likely to change in response to community practices and needs (Lievrouw, 2006; Rice & Gattiker, 2001). Such changes may increase the likelihood and rate of adoption and ensure a better fit between the innovation, its users, the tasks it was designed to support, and the social environment in which it was introduced (Barrett & Stephens, 2016; Berg, 2001; Cain & Mittman, 2002; Hanseth & Aanestad, 2003). Here, early adopters can have a heavy influence on the evolution of both the innovation itself and the community norms established around its use, which may improve the innovation for later adopters, potentially increasing compatibility and reducing complexity (Rice & Gattiker, 2001; Tidd, 2010). However, when early adopters are atypical of the majority of the population, for example, possessing technical skills others do not, this process can skew development of innovations to favor of the needs and requirements of this group rather than those of the community as a whole (Tidd, 2010).

Individual Factors in Diffusion

Rogers' (2003) distinguished individual adopters in a diffusion process by the point in that process in which they choose to adopt the innovation. Diffusion typically

tends to follow a normal, bell-shaped curve when plotted over time or an S-shaped curve when plotted by the cumulative number of adopters. The innovation is first adopted by a few innovators within a social system. Next, the adoption rate gradually accelerates as more individuals adopt, until it eventually levels off as fewer individuals remain who have yet to adopt the innovation. Rogers (2003) identifies five adopter categories based on this normal distribution:

1. *Innovators*, the first 2.5% of individuals in a social system to adopt an innovation,
2. *Early adopters*, the next 13.5% to adopt,
3. *Early majority*, the next 34%,
4. *Late majority*, the 34% to the right of the mean, and
5. *Laggards*, the final 16%.

Other researchers have limited the classes of adopters to two: *innovators*, who make adoption decisions independent of the influence of social pressures, and *imitators*, who do not (Bass, 1969; Botelho & Pinto, 2004; Chu, Liu, & Wu, 2010).

Rogers (2003) provided broad generalizations about each adopter category as an ideal type. The innovators tend to have wide social networks, are motivated to seek out new information, and often function as gatekeepers in introducing an innovation into a social system, though they are not necessarily the members of the social system with the most influence. Early adopters, on the other hand, are often opinion leaders, capable of influencing others within the system to subsequently adopt an innovation. Later categories of adopters are characterized as tending to exhibit fewer leadership

behaviors, more skepticism toward innovations, and greater reliance on tradition. Opinion leaders in diffusion studies are identified by both their personal innovativeness and their degree of influence within their social system; however, studies have found that in structured communities and those with established hierarchies, as is often the case in research-intensive organizations, innovativeness and opinion leadership may not be correlated (Valente, 1995).

Rogers (2003) defines innovativeness as "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system" (p. 22). As such, innovativeness, while found to be positively correlated with adoption, can be difficult to measure as a fixed trait and may vary by context or by type of innovation (Agarwal & Prasad, 1998; Cain & Mittman, 2002). Agarwal & Prasad (1998) define personal innovativeness as "the willingness of an individual to try out any new information technology." By contrast, Styhre & Börjesson (2006) define innovativeness in the context of organizations as "the ability of an organization to orchestrate the development of new goods and services." This definition is somewhat parallel to Joseph Schumpeter's definition of innovation itself as the realization of "new combinations" of creative ideas and existing resources (Schumpeter, 1934). Innovativeness as the willingness to *adopt* new combinations and innovativeness as the ability to *create* new combinations are two different concepts and how well-correlated they might be in any particular context may require further study. In some cases, innovativeness has been found to be negatively correlated with adoption of innovations,

such as in the case of disappointing or low-value innovations, for which innovators are often the first to seek out and discover negative information (Greve, 2011).

In addition to an individual's personal innovativeness and position within a social system, individual factors that have been shown to influence innovation adoption include attitudes toward technologies; confidence; demographic factors such as age and gender; existing knowledge; education; research discipline or specialty; position within an organization or social system; prior experience with similar technologies; and self-efficacy (Alshamaila, Papagiannidis, & Li, 2013; Eger, Godkin, & Valentine, 2001; Greenhalgh, Robert, Bate, Macfarlane, & Kyriakidou, 2005; Jeyaraj et al., 2006; Karsten & Laine, 2007; Lennon et al, 2017; Pelletier, Jethwani, Bello, Kvedar, & Grant, 2011; Putzer & Park, 2012; Rice et al., 1990; Schaper & Pervan, 2006; Wang et al., 2014).

It is important to note that adoption decisions may be made at the organizational rather than the individual level, in which case organizational characteristics, such organizational innovativeness and structure, will come into play in initial adoption decision instead (Berg, 2001; Engström, Lindqvist, Ljunggren, & Carlsson, 2009; Fichman, 1992; Greenhalgh et al., 2005; Jbilou, Landry, Amara, & El Adlouni, 2009; Jeyaraj et al., 2006; Rahimi et al., 2009; Tsai & Hung, 2016; Ward, 2013). The study of organizations as adopters and as the social context in which adoption takes place, and the specific considerations for diffusion research when an adoption decision is made at the organizational level and use by individuals is subsequently mandated, will be discussed further in the next two sections.

Social and Environmental Factors in Diffusion

For interactive innovations to be of use to individuals, they must be adopted by others within the community with whom the individual communicates. Markus (1987) defines *community* as "a group of individuals with some common interest and stronger communication flows within than across its boundaries: Examples are an invisible college of researchers, a business organization, or a department within a firm" (p. 492). A large organization or network of organizations may encompass many smaller communities, for example, multiple individual departments or research working groups.

In diffusion studies, organizations have been studied as both adopters of innovations and as the environments in which adoption takes place (Fichman, 1992; Jeyaraj et al., 2006). Studies at the macro-level analyze organizational decisions to adopt innovations, while studies at the micro-level consider the adoption decisions of individual end-users, which are often influenced by the organizational environment, culture, and policies (Michel-Verkerke & Spil, 2013). Macro-level decisions may include mandating use of innovations by individuals, making these adoption decisions non-voluntary (Venkatesh et al., 2003). Organizations have also been studied as the meso-level of innovation decision-making, as organizations themselves are often subject to the decisions of even larger governing and policymaking bodies, such as when technology acquisition decisions are made at the level of a larger network, or government regulations regarding information management and security impact local information practices (Berg et al., 2003; Cain & Mittman, 2002; Cranfield et al., 2015).

Organizational social and environmental factors that have been found to influence the innovation adoption decisions of individuals include: availability of supporting technologies, such as supporting hardware and software, and ease which innovations can be integrated with existing technologies already in use; existing organizational culture, norms, communication patterns, and work processes; internal technical support and availability of training; organizational policies; organizational communication about innovations during and prior to diffusion; organizing vision; perceptions of management support; social dynamics within the organization; and the visibility of use within an organization (Ash, 1997; Bandlow, 2015; Cheney, Block, & Gordon, 1986; Fichman, 1992; Greenhalgh et al., 2005; Ishak & Newton, 2016; Kemper, Uren, & Clark, 2006; Lennon et al., 2017; Leslie et al., 2017; Liu, Dedehayir, & Katzy, 2015; Miranda et al., 2015; Moore & Benbasat, 1991; Schaper & Pervan, 2007; Tjora & Scambler, 2009; Wang et al., 2014). As with other systems, the size, shape, and density of both formal and informal communication networks within an organization and the placement of innovators, high-resource individuals, and opinion leaders within those networks will likely influence the success, rate, and patterns of diffusion (Bohlmann, Calantone, & Zhao, 2010; Czepiel, 1974; Oliveira & Martins, 2010; Rice et al., 1990). Here, social network analysis can provide valuable data for diffusion researchers (Anderson, 2002; Scott, 2001).

For decisions at the organizational level, the characteristics of organizations that have been found to significantly influence adoption of innovations include: absorptive capacity; business needs; collaborative practices within the organization; compatibility

of the innovation with organizational strategy; diffusion of the innovation within the competitive environment, or adoption by peer organizations; external pressure; dominant management orientation and characteristics; existing information technology infrastructure; organization size; organizational innovativeness; organizational complexity; security practices and policies; strategic orientation; slack resources (such as the time and money necessary for innovation testing and adoption); support from suppliers for externally acquired innovations; and top management support (Alshamaila et al., 2013; Bocquet & Brossard, 2007; Bocquet, Brossard, & Sabatier, 2007; Cheney et al., 1986; Čudanov & Jaško, 2012; England et al., 2000; Fichman, 1992; Fitzpatrick, Melnikas, Weathers, & Kachnowski, 2008; Greenhalgh et al., 2005; Jbilou et al., 2009; Jeyaraj et al., 2006; Neale, Murphy, & Scharl, 2006; Oliveira & Martins, 2010; Roberston & Gatignon, 1986; Tsai & Hung, 2016; Wu & Wu, 2012; Yang, Sun, Zhang, & Wang, 2015). For health care organizations, the highly specialized nature of the work, and the need for specialists who possess critical knowledge to be able to share it with others, can increase interdependency among individuals and departments, and increase the need for tools that enhance information sharing, which may shape adoption decisions (Tsai & Hung, 2016).

How an innovation is initially introduced may impact a number of these factors, and ultimately, the diffusion process (Appelbaum, Habashy, Malo, & Shafiq, 2012; Kotter, 2012; Starmer et al., 2014). Factors such as how the benefits of innovation are communicated by leadership, how these benefits are tied to organizational values, and

how obstacles are addressed throughout the diffusion process can impact whether a decision to adopt is made or ultimately confirmed (see Kotter, 2012).

While most research at the organization level is from the perspective of encouraging diffusion, Greve (2011) found that in the case of disappointing, or low value innovations, negative information either directly received from or inferred from the behavior of previous adopters could stop a diffusion process. Ability to identify and halt the spread of an innovation is an important, though less studied, aspect of diffusion, as the consequences of the introduction of a new technology are often unintended, and may negatively impact communication, relationships, quality of output, or workflow (Ash et al., 2007; Greve, 2011; Wu et al., 2013).

In addition to factors within an environment that can be potentially controlled, at least to some extent, by leaders or members of the social system, a number of external factors have also been shown to impact diffusion and adoption. Beyond those previously mentioned, such as adoption by peer organizations and external pressure, these may include external political environments; laws and regulations that impact information sharing; perceived liability issues; and the shape and complexity of markets (Lennon et al., 2017).

Markus' (1987) definition of community quoted earlier in this section highlights the fact that most individuals in a diffusion process are members of more than one community. For example, medical researchers may have various roles and levels of influence within their own organization, within the larger university system in which that organization exists, within their research discipline, within the various professional

organizations and networks to which they belong, and within the different social groups and collaborative projects they may be part of. Further, the same individual can play multiple roles within the same organization at different points—for example, the role of researcher, the role of practitioner, and the role of administrator—and all of these roles can influence information behaviors, as well as potential exposure and receptivity to new innovations (Cain & Mittman, 2002; Granovetter, 1973; Greenhalgh et al., 2005; Tjora & Scambler, 2009). Again, it is important to consider that in research-intensive organizations, the values, norms, and communication practices of larger disciplinary and professional communities are likely to impact the communication and innovation adoption behaviors of individuals and working groups (Becher, 1991; Greenhalgh et al., 2005; Habermas, 1996; Logino, 1990; Rahimi et al., 2009; Reychav & Aguirre-Urreta, 2014).

Use-Related Factors

Use-related factors are those most closely related to the implementation phase of an adoption decision process and relate to understanding the specific uses made of the innovation as well as the way these uses impact and are impacted by the contexts of diffusion (Ackerman et al., 2012; Ammenwerth, Iller, & Mahler, 2006; Sittig & Singh, 2010). While these factors have appeared in prior diffusion studies, they have not typically been examined as a category.

In organizational diffusion studies, one important use-related factor is to what extent use of the innovation by individual adopters is perceived as voluntary. Innovations are often adopted at the organizational level and use by individuals within

the organization is subsequently mandated. While few diffusion researchers have studied the distinction, Greenhalgh et al. (2005) note that there is continuum between "pure diffusion," which occurs informally at the level of peer communities, and "active dissemination," in which diffusion is planned, formalized and hierarchical. Voluntariness of use was not a factor considered in the original diffusion of innovations framework but does appear in later technology adoption models including the unified theory of acceptance and use of technology (UTAUT) developed by Venkatesh, Morris, Davis, and Davis (2003). Fichman & Kemerer (1999) note there are often "assimilation gaps" between organizational acquisition of an innovation and actual use by individuals within the organization. Even if innovation use is mandated by some authority, individuals within an organization or community may not necessarily adopt and use the innovation as intended, particularly if other barriers to adoption are not addressed; in fact, this may increase user resistance to the innovation (Barrett & Stephens, 2016; Granlien, Hertzum, & Gudmundsen, 2008).

As noted in the prior subsection, contexts of use can also have a substantial impact on users' perceptions of the attributes of an innovation. In the case of an innovative ICT, attributes such as complexity and relative advantage may be evaluated differently by different users, not based on how well an innovation meets generally accepted standards of usability or good information technology design, but also on how well the innovation is suited to their particular work processes and ways of communicating, and its overall impact on their own workflows (Ackerman et al., 2012; Ammenwerth et al. 2006; Berg et al., 2003; Bevan, 2001; Nath, Hu, & Budge, 2016). For

example, Nicolini (2006) found that telemedicine technologies designed to speed access to information actually slowed down interaction between health care professionals and patients and created duplicate work for nurses and physicians due to the structured and hierarchical way information was stored and displayed within the system, which did not match the actual information and communication practices of the individuals in the environment. Interfaces, processes, and ways of classifying information are sometimes built into a system based upon the needs of one environment or group of users and prove inappropriate when the system is deployed in another environment, or else need to be changed over time as organizations evolve, new research discoveries are made, or additional innovations are introduced to the system (Barrett & Stephens, 2016; Berg et al., 2003; Bowker & Star, 2000; Hanseth & Aanestad, 2003). Adoption of an innovation may depend on how well it can be adapted to the tasks for which it is being employed, and a high level of adaptability may mean that the innovation will change substantially between the knowledge phase and the adoption phase, or between adoption and full implementation (Hanseth & Aanestad, 2003; Tidd, 2010).

Defining what constitutes full adoption of an innovation may also be difficult for studies of complex interactive technologies, as users may opt to utilize only some features of a technology; to use the technology only for some types of information; to use the technology to communicate with some members of the community, but not others; or to maintain two systems of communication rather than fully abandoning old systems and practices for innovative ones (Greenhalgh et al., 2005; England et al.,

2000; Nentwich & König, 2012; Sittig & Singh, 2010). Jeyaraj & Sabherwal (2008) distinguish between full adoption of an innovation, in which the innovation is used to its fullest extent; partial adoption, in which only some of the innovation's features are used or the innovation is used only for particular tasks; and experimentation, in which the user tries the innovation for a limited time, possibly in order to gain full knowledge of its features or functions. This last is closely associated with an innovation's trialability and does not represent adoption, though it may look like it at a particular point in time. Here, a qualitative approach, whether undertaken alone or in combination with a quantitative one, can be helpful for fully understanding innovation use and use context, including whether such use represents full adoption (Sittig & Singh, 2010). For example, Trudel et al. (2017), in their study of electronic medical record (EMR) systems in primary care medical practices, found that physicians tended not to use advanced EMR functionalities. This was connected to the fact that the knowledge these physicians were given from system vendors consisted primarily of information about what the innovation was and what it did (know-what), rather than information on the rationales for adoption (know-why), or strategies for adopting, implementing, and assimilating the innovation in an organizational context (know-how).

The observability of an innovation, the degree to which the results of an innovation are visible to others (Rogers, 2003), is a final important use-related factor; here again, in health care organizations, the ultimate impacts of communication innovations on patient outcomes and the quality of care are often the most difficult to

observe and quantify (Djellal & Gallouj, 2007; Greenhalgh et al., 2005; Moore & Benbasat, 1991; Ward, 2013).

Sociotechnical Approaches to Studying Diffusion and Adoption

Research from a sociotechnical systems perspective has focused on the ways information technologies both shape and are shaped by societies and human interactions (Van House, 2004). While some claim that diffusion research as a whole has tended to lack a social dimension (Aleke et al., 2013), the social system in which diffusion takes place is an important component of the theory (Rogers, 2003), and perhaps especially important in the case of interactive innovations. Understanding how communities function as social systems and how existing scientific and professional communication practices impact the exchange of information within these systems may present a fuller and more inclusive picture of the diffusion of interactive innovations, as well as identify potential factors impacting adoption that are difficult to quantify.

Sociotechnical Research and the Diffusion of Innovations

Multiple researchers have provided frameworks for examining communities as social systems and the role interactive technologies play within them. Sociotechnical research approaches are ideal for examining the dynamics of how information technologies both shape and are shaped by the systems of which they are a part (Ackerman et al., 2012; Berg et al., 2003; Opazo, 2012; Sittig & Singh, 2010; Van House, 2004; Ward, 2013). Researchers have studied the social processes by which scientific knowledge and technologies are developed, as well as the way these

innovations, once deployed and in use, subsequently shape societies (see Latour, 1987; Latour & Woolgar, 1971; Lievrouw, 2006; Suchman, Blomberg, Orr, & Trigg, 1999; Van House, 2004).

A sociotechnical approach to studying interactive innovation adoption can provide researchers with a more complete picture of complex innovation adoption decisions, including the ways these decisions both impact and are impacted by the environment in which they are made, how individuals understand the innovation and what it does, and the role individuals believe the innovation plays or could play in their work and daily lives (Sittig & Singh, 2010; Tjora & Scambler, 2009; Ward, 2013). Such an approach may also help identify cases in which individuals' use or understanding of the innovation substantially differ, such as when differing views of an innovation's role and utility exist between researchers and administrators, or between practitioners from different disciplines or specialties (Ash et al., 2007; Ward, 2013).

A qualitative or mixed methods approach can help researchers identify factors shaping diffusion that may not be picked up by quantitative diffusion research using existing instruments and frames; for example, through sociotechnical analysis, Ackerman et al. (2012) discovered one barrier to adoption of a computerized diagnostic kiosk in hospital emergency departments was a lack of certainty as to the kiosk's exact location—either physically or socially—in the processes of patient registration, diagnosis, and examination. Sociotechnical research has also examined how the introduction of interactive innovations shape the networks in which they are introduced. Leslie et al. (2017) found the use of health information technology created unintentional

silo effects by physically isolating users, isolating user-generated data, and creating social silos when communication began to occur more frequently through the system instead of face-to-face, all of which was believed to have a detrimental impact on patient safety and care. Wu et al. (2013) found that use of smartphones and alphanumeric pagers among teaching hospital residents improved efficiency, but had unintended consequences, including negative impacts on interpersonal communication and collaboration, and led increased interruptions and confusion around which communication channels to use (Wu et al., 2013). Researchers have found that use of ICTs in research and clinical settings have in some cases profoundly disrupted workflows, the communication of information, the relationship between health care providers and patients, research strategies, established organizational hierarchies, and researcher and professional roles and responsibilities (Ash et al., 2007; Berg, 2001; Borgman, 2007; Cresswell et al., 2010; Leslie et al., 2017; Patel, Kushniruk, Yang, & Yale, 2000; Wu et al., 2013). Some researchers maintain that advances in information technology have profoundly disrupted the scientific method itself and introduced entirely new research paradigms in health and other fields (Hey, Tansley, & Tolle, 2009).

The economist Joseph Schumpeter coined the term "creative destruction" to describe the economic and societal impact of new innovations (Carayannis, Ziemowicz, & Spillan, 2007). Innovations, the realization of "new combinations" of creative ideas and existing resources, lead to creative destruction of existing economic and social structures and the creation of new ones, with the full impact of a particular innovation dependent on both the type of innovation and whether or not it is diffused. When the

diffusion process nears its end, a new economic equilibrium is achieved, which may again be disrupted by future innovations (Carayannis, Ziemowicz, & Spillan, 2007; Dahms, 1995; Kurz, 2012; Schumpeter, 1934). Topol (2013) argues that the rise of digital information technologies, including electronic health records, collaboration tools, and new technologies for data collection and sharing are leading to the "creative destruction of medicine," changing not only how medical information is communicated, but the practice of medicine itself and the relationship between physician and patient.

Whether or not interactive innovations result in full-scale creative destruction of an economic or social sector, they do profoundly shape it. Research from an actor-network theory (ANT) perspective goes beyond examining technology's impact on social networks of communicating humans to conceptualize technologies themselves as actors within the network having, to some extent, their own agency (Cresswell, Worth, & Sheikh, 2010; Latour, 2005; Van House, 2004). ANT has been used in diffusion studies as a methodological framework for understanding the decisions and social processes used in the creation of innovations as well as the active role technologies play in social systems once they are deployed. This framework can aid in understanding the roles communications technologies play in both mediating and shaping communication processes (Cresswell et al., 2010; Harisson, Laplante, & St-Cyr, 2001; Opazo, 2012; Zendejas & Chiasson, 2008).

Some sociotechnical researchers studying ICTs have invoked Habermas' (1987) concepts of lifeworld and system to explain technologies' impact on social structures. The lifeworld is the set of beliefs, practices, and structures of communication shared by

a particular community and is the means by which social integration is produced and reproduced via communicative action (Backlund, 2005; Habermas, 1987). The system represents pre-defined formalized sub-systems which rely on other means of reproduction; these subsystems include the economic system, which relies on money, and the administrative system, which relies on institutional power (Habermas, 1987). Colonization of the lifeworld is said to occur when systemic mechanisms suppress social interaction and limit communication in situations in which reproduction of the lifeworld is at stake and consensus-based decision-making should occur (Backlund, 2005; Habermas, 1987). When interactive innovations are employed in communicative action, they by definition shape the lifeworld. They may also constrain as well as enable communicative action (Markus, 1987). In cases where there is a mismatch between the values assumed by the designers of an ICT and the values held by its users, particularly when the values embedded in ICTs are those shaped by economic and administrative forces, the technology can constrain rather than enable communication and its use lead to loss of social cohesion and disruption of work practices and norms, which some researchers have characterized as colonization or technification of the lifeworld (Habermas, 1987; O'Donnell & Henriksen, 2002; Standing, Standing, & Law, 2013; Tjora & Scambler 2009). According to Standing, Standing, & Law (2013) this can happen when interactive innovations are adopted by organizations in "an instrumental way with the main objective of improving productivity rather than understanding." Understanding the values in play in both the design of innovations and the social

systems in which they are deployed, including areas in which values may be incompatible, can help prevent such loss of cohesion.

Values in the Diffusion of Interactive Innovations

Values are an important component of human decision making, including the decision to adopt a new innovation. For the purposes of this research, *value* "refers to what a person or group of people consider important in life" (Friedman, Kahn, & Borning, 2009, p. 349). Researchers who study values in design examine "individual and social values as equally important inputs to the technology design process" (EVOKE, 2015). Some examples of values which can inform technology design include freedom, helpfulness, creativity, equality, wealth, and justice, among other values (Cheng & Fleischmann, 2010). In the case of interactive innovations, values play a role in decisions made at the very beginning stages of the design, including those related to how to classify information and present it to users, what standards and specifications to use, and what workflows and types and patterns of communication the innovation will support (Berg, 2001; Bowker, 2005; Bowker & Star, 2000; Friedman & Kahn, 2008; Friedman, Kahn, & Boring, 2008; Knobel & Bowker, 2011). Once these decisions are made, these values become an inherent and often invisible part of the innovation, and if it is successfully diffused within a social system, will ultimately play a role in shaping the system itself (Berg, 2001; Bowker, 2005; Lievrouw, 2006). Individual, professional and cultural values can shape not only an innovation, but also its eventual adoption and use in context (Friedman et al., 2008; Goodman, 2008; Kotter, 2012). To the extent that the values and norms supported by an interactive innovation lack compatibility with the

social systems in which it is being introduced, this can lead to rejection of the innovation or the need for extensive reinvention or reprogramming before diffusion is achieved (Berg et al., 2003; Friedman & Kahn, 2008). In cases where use is mandated despite the lack of fit, adoption of the innovation can interfere with communication and cultural reproduction of the lifeworld (Dillard & Yuthas, 2006; O'Donnell & Henriksen, 2001; Ross & Chiasson, 2011; Tjora & Scambler, 2009).

Scientific values which both shape the creation of ICTs as well as potentially shape the contexts of their use are those values that Longino (1990) referred to as the constitutive values of science, or those which constitute "the sources of the rules for determining what constitutes acceptable scientific practice or scientific method" (p. 4). While there is some disagreement as to how exactly to define those values, and values may differ by discipline or profession, in general the constitutive values of science are likely to include empirical observation and testing of hypotheses via appropriate scientific methodology, sharing of research results, accurate reporting of data and experimental results, conduct of ethically responsible research, professional credit for novel discovery, and values related to proper evaluation and acceptance or rejection of scientific theories (Allchin, 1988; Couvalis, 1997; Lacey, 1999; Longino, 1990; Okasha, 2002). In research-intensive environments in the empirical-analytic sciences, these constitutive values profoundly shape actors' understanding of the four validity claims that, according to Habermas (1984, 2001) determine whether a particular speech act is appropriate:

- *Intelligibility*—Is the speech act intelligible or capable of being understood by the intended receiver?
- *Truth*—Is the speech act factually or observably true?
- *Normative rightness*—Is the speech act appropriate, given existing social norms?
- *Truthfulness* or *sincerity*—Is the speech act sincere?

The scholarly communication system as it presently exists, including informal and formal networks of communication, the emphasis on the publication of research results, and the process of peer review for scientific publications, reflects the constitutive values of science (Longino, 1990).

Innovative efforts to translate research into practice or turn new ideas into marketable technologies are also value-laden activities (Greenhalgh et al., 2015; National Academies, 2007). Existing values impact the introduction and development of new technologies within a social system, and scientific and professional social systems are not an exception (Allchin, 1988). Here again, it is important to note that not all disciplines are the same (Becher, 1991; Borgman, 2007; Cooke & Hilton, 2015). Sociotechnical studies of ICT deployment in health care settings have noted cases of value mismatch between the values assumed by computer scientists and the designers of information systems and the values of those physicians expected to be users of the systems (May, Mort, Williams, Mair, & Gask, 2003; Ward 2013). An approach to information system design in which members of the expected user community are the primary designers or have extensive input at all stages of the design process may be ideal, as the values, needs, contexts and work practices of local users can be taken into

account during development, but this may not necessarily be practical in all situations, particularly in cases where needed resources or innovation design capacity do not exist within an organization to develop an innovation locally and commercial or externally developed products need to be purchased and brought in house (Carroll & Rosson, 2006; Cranfield et al., 2015; Greenhalgh et al., 2005; Khatri & Gupta, 2016; Starmer et al., 2012; Ward, 2013).

Communication within health care environments is shaped particularly by medical values, defined as those specific to the medical profession, "directly linked to the medical work that must be accomplished for a case and to the conditions in which this work is accomplished" (Nurok & Henckes, 2009, p. 505). These can include health and safety, privacy and confidentiality, and above all, serving the interest of patients, which Goodman (2008) defines as a core value.

Habermas (1996) makes a distinction between interaction and work. The realm of interaction is the realm of communicative action, based on social knowledge and the understanding of social norms. Behavior that violates these norms is deviant behavior, which may be punished by social sanctions. Work is the realm of purposive-rational action, which may be either instrumental action, based on empirical knowledge, or rational choice, based on strategic application of analytic knowledge. Behavior which displays a lack of empirical or analytic knowledge is incompetent behavior, which may be "punished" by failure. In research-intensive health care environments, interaction and work may be difficult to separate, and interactive innovations deployed in such an

environment are likely to be used to support, and will consequently shape, communicative action, instrumental action, and rational choice.

The Diffusion of Interactive Innovations in Research-Intensive Environments

An innovation may be a particular object or type of technology, it may be an idea or practice, or may represent all of the above (May, Mort, Williams, Mair, & Gask, 2003; Rogers, 2003; Roth, 2015; Van House, 2004). Innovations deployed in research-intensive contexts can profoundly shape those contexts in large and small ways. An example of a large-scale technological change for research communities which involves the adoption of innovative new ideas, technologies, and practices is Jim Gray's concept of data-intensive science as the "fourth paradigm" of science. Researchers doing data-intensive science have adopted new technologies for data capture and simulation. The capabilities of these technologies and the sheer amount of data that can now be produced, captured, and analyzed has changed the processes of doing science itself (Hey, Tansley, & Tolle, 2009). The amount of data that must now be managed and the rise of institutional mandates requiring formal data management as well as in many cases, data sharing, mean that researchers in the health sciences and other fields are not only adopting new technological tools, but new practices and new ways of communicating that are, at present time, still unevenly diffused (Borgman, 2015; Poole, 2015; Tenopir et al., 2011; Tenopir et al., 2015). While data sharing practices are in some way compatible with existing values, in that they involve knowledge sharing and allow for greater possibility of replication of research results, at other times the need to

accommodate values and communication norms in data sharing may present social and technical challenges for researchers, policymakers, and systems designers. There is currently no established peer review system for raw data, for example, and data sharing may be contingent upon researchers' need to be appropriately credited for the data, or the need to ensure the privacy and confidentiality of human subjects (Borgman, 2015; Tenopir, 2015).

Social media or Web 2.0 technologies, a term which includes tools such as social networking sites, wikis, blogs, and other web-based tools that enable interaction among users as well as the creation and sharing of user-generated content, are an example of a class of interactive innovations that, while widely diffused in other contexts, have not been as widely adopted as anticipated in scientific and medical contexts. Studies have found that while users see some relative advantage to using these tools for research communication and collaboration, they also report barriers such lack of compatibility with existing workflows, communication norms, and scientific values; lack of time for social media use; lack of academic or professional reward for these activities; concerns related to privacy; and lack of peer review for information shared via these systems (Acord & Harley, 2013; Gu & Widen-Wulff, 2011; McGowan et al., 2012; Nentwich & König, 2012; Proctor et al., 2010; Nicholas et al., 2014; Tenopir et al., 2013).

By contrast, the Internet and multiple related innovations—including electronic journals, online scholarly databases, email, and search engines—are at this point widely diffused in professional and research communities, and have been shown to have some impact on physician and researcher behaviors when it comes to access, reading, and

searching for information, and formally and informally communicating with peers, as these innovations now make information easier to find, share, and, in many cases, access; however, overall traditional patterns of communication, in particular the primacy of peer-reviewed research journal articles in formal communication systems, have to this point largely remained unchanged by adoption of these innovations (Barjak, 2006; Chew, Grant, & Tote, 2004; Kling & Callahan, 2003; Nicholas et al., 2014; Tenopir, King, Christian, & Volentine, 2015). Here again, behaviors also vary by discipline (Tenopir et al., 2015).

Interactive Innovation Adoption in Health and Medicine: Specific Considerations for Research

A number of studies have looked at the specific factors that influence the diffusion of interactive innovations and their adoption by various communities of professionals in the fields of health and medicine, with many of these focusing on the adoption of electronic health records, telemedicine, and other e-health technologies (see Ammenwerth et al., 2006; Barrett & Stephens, 2016; Cain & Mittman, 2002; Cranfield et al., 2015; Day & Norris, 2007; de Grood et al., 2016; Engström et al., 2009; Greiver et al., 2011; Jbilou et al., 2009; Kemper et al., 2006; May et al., 2003; Mennemeyer, Manachemi, Rahurkar, & Ford, 2016; Nath et al., 2016; Oliver-Mora & Iñiguez-Rueda, 2017; Ward, 2013; Weigel & Hazen, 2013; Weigel, Rainer, Hazen, Cegielski, & Ford, 2012). Interactive innovations can improve, or in some cases constrain, communication between professionals, between physicians and patients, and between medical experts and the general public (Oliver-Mora & Iñiguez-Rueda, 2017).

Djellal & Gallouj (2007) note that many new interactive health technologies are not purely ICTs, but hybrid medical technologies that have an ICT component, such as monitoring systems, automatic diagnostic equipment, and video surgery; whether the same factors influence adoption of hybrid technologies, and what role reciprocal interdependence plays in these adoption patterns, warrants further study. While innovation adoption in health and medicine is often driven by organizational administrators, it can be driven by physicians themselves, or even by patients with a specific information need (Lee, Hirscheld, & Wedding, 2016; Oliver-Mora & Iñiguez-Rueda, 2017).

In 2005, Greenhalgh et al. published a large, comprehensive literature review commissioned by the U.K. Department of Health in which the researchers reviewed over 500 studies with potential relevance to the diffusion of innovations within health service organizations and developed a model for future research. While not specifically focused on interactive innovations and lacking the component of reciprocal interdependence unique to these innovations, the Greenhalgh model does serve as a potential aid for research, though the researchers themselves note that local context, setting, and timing need to be fully considered in undertaking any study of diffusion in any particular organization. Whether the same instruments for studying diffusion can be successfully applied (with some adjustment for local context) to public, private and academic organizations; organizations in different geographical locations or with different dominant cultures; and research-focused as well as service-focused organizations still has no definitive answer (Djellal & Gallouj, 2007; de Grood et al.,

2016; Greenhalgh et al., 2005). The type of approach a diffusion study will take may depend largely on how an organization is conceptualized by the diffusion researcher and by the members of that organization (Djellal & Gallouj, 2007).

In addition to more generalized barriers to innovation adoption that may be common to research-intensive organizations of all types, some of the specific barriers to diffusion mentioned frequently in diffusion studies in health care environments include the ability to adapt the innovation to local needs and provider contexts; concerns related to patient privacy and the security of information; data errors and the potential for information misinterpretation; liability; medical documentation requirements; the potential disruption of communication between providers and patients; user expertise; and the ultimate impacts of the innovation on such factors as medical costs, patient safety, the prevention of medical errors, and the quality of patient care (Ammenwerth et al., 2006; Barrett & Stephens, 2016; Daim et al., 2008; de Grood et al., 2016; England et al. 2000; Fitzpatrick et al., 2008; Greiver et al., 2011; Kemper et al., 2006; Lee et al., 2017; Lennon et al., 2017; Meigs & Solomon, 2016; Newman, Bidargaddi, & Schrader, 2016; Oliver-Mora & Iñiguez-Rueda, 2107; Tjora & Scambler, 2009; Tsai & Hung, 2106). The lack of empirical evidence for an innovation's effectiveness and impact on patient outcomes can also affect adoption (Saner & van der Velde, 2016).

Availability of appropriate supporting technology in the environment can also be an important factor if the innovation is technology-based (Leslie et al., 2017). Some organizations have examined allowing medical professionals to bring their own hardware, including personal mobile devices, into the workplace for professional use. A

study of nurse managers found that concerns related to use of personal devices for information sharing in a health care setting included potential risks to the privacy and security of patient information and a potential for decreased productivity and a negative impact on patient care, particularly in the absence of strong guiding policies on device use (Martinez, Borycki, & Courtney, 2017). A survey of Toronto medical students found that a large majority of them used personal phones for patient-related communication, and while most felt use of the device enhanced their efficiency and ability to provide patient care, there were concerns about patient privacy and confidentiality; despite this, nearly a quarter reported using personal phones to text and email confidential patient information (Tran et al., 2014). Wu et al. (2013) found that despite privacy concerns, some residents still used personal smartphones for patient-related communications, even when official smartphones were provided for them by the organization.

Also noted were the potential for interactive innovations to improve or impede intra-organizational communication in larger networks and between health providers (Day & Norris, 2007; Djellal & Gallouj, 2007; Mennemeyer et al., 2016). In research-intensive health care environments, information is often sought collaboratively; systems deployed in health care environments not only need to adequately support search and retrieval activities, but also the professional collaboration activities that accompany them, which may involve both remote or asynchronous communication activities between experts in multiple fields (Nürnberger, Stange., & Kotzyba, 2015; Tsai & Hung, 2016). Time is a critical factor in health and medicine; this is often both a valuable and scarce resource, and systems that are complex, take time to master, or slow traditional

workflows are more likely to be rejected (Chew et al., 2004; Cranfield et al., 2015; de Grood et al., 2016; Granlien et al., 2008; Karsten & Laine, 2007) or likely to encourage the development of workarounds that impact use of the system as intended (Meigs & Solomon, 2016). At the organizational level, the related concept of slack—the time and resources needed to test innovations, make adjustments, and incorporate them into work practices—is also often scarce (Berwick, 2003; Greiver et al., 2011).

Factors related to innovations, the anticipated users of the innovations, the contexts of use, and the specific actual and expected uses of innovations may be difficult to separate and a number of interactions are likely to occur (Greenhalgh et al., 2005). User needs, ways of communicating, and the appropriateness of use of a particular innovation may vary both by activity and actor; for example, different methods and media may be utilized when one is collecting data, interacting with patients, or informally communicating with peers; in patient care settings, appropriateness may vary by the urgency of the communication (Berg et al., 2003; England et al., 2000; Rahimi et al., 2009; Tjora & Scambler, 2009; Wu et al., 2011; Wu et al., 2013).

The approach this research takes to examining diffusion of interactive innovations in research-intensive health care environments looks at four broad categories of factors identified in previous studies of diffusion: those related to the innovation, those related to the current and potential users, those related to both the immediate and external social and environmental contexts in which an innovation is deployed, and those related to the actual uses of the innovation in context. The next section presents the model and the proposed research methodology.

CHAPTER THREE
MODEL AND METHODS

This research involves a mixed-method study examining adoption of two different interactive innovations by physicians in training at an academic medical center. In this section, I present the research model and discuss the research location, the study population, the innovations under study, and the two-phase mixed-method research design.

The Model

The Pollock Model of Interactive Innovation Adoption (PMIIA) was synthesized from the evidence of the literature review and represents a new model for the study of interactive innovation adoption in research-intensive environments (Figure 1). It includes four broad categories of factors I hypothesize will impact the adoption of interactive innovations in research-intensive environments. The quadrants are close together, positioned to suggest overlap at the boundaries and at the point of adoption, as in some cases the factors themselves overlap and are dependent on each other. For example, determining an innovation's compatibility with task(s) and environment(s) requires knowledge of the environments, the uses to which the innovation will be put in the performance of those tasks, and the individuals who will be using the innovation. There is also space in the model for potential unknown factors impacting diffusion and adoption that may be uncovered in the course of the research.

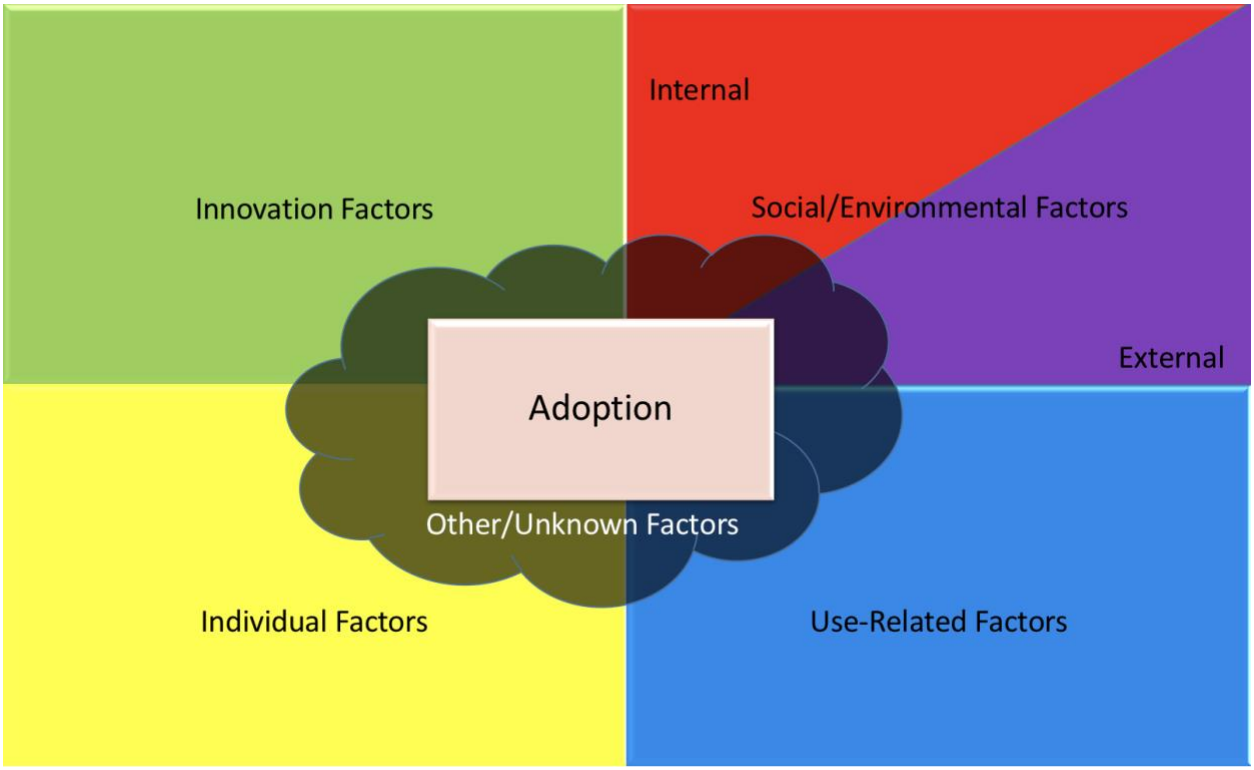


Figure 1. The Pollock Model of Interactive Innovation Adoption.

- **Innovation factors** are those related directly to the innovation itself. These include, but are not limited to, its features; design; types of use supported; ease of use; compatibility with potential adopters' information needs, task(s), and environment(s); trialability, and relative advantage over other options.
- **Individual factors** are those related to an individual capable of making adoption decisions. Depending on which level the study of adoption takes place, individual factors might relate to persons or organizations. These include, but are not limited to, personal or organizational innovativeness; demographic factors such as age, national origin, or gender; previous experiences with similar innovations;

individual information and communication needs; discipline or specialty; role(s) within the larger environment; previous education; and collaboration practices.

- **Social and environmental factors** are those related to the larger social environment in which adoption decisions take place. This quadrant is divided to indicate that in a research-intensive environment, adoption can be impacted by both internal and external social and environmental factors. *Internal factors* are those specific to the environment in which adoption decisions are made, such as local organizational policies regarding communication of information, or the communication norms of a specific working group. *External factors* are those social and environmental factors that are external to the immediate environment, but impact information sharing and communication within it, such as federal laws that regulate communication, or the information sharing norms of an entire discipline. Social and environmental factors include, but are not limited to, organizational structure; social networks; policies and regulation; the availability of training and support; social norms and culture; relationships with external entities and outside vendors; information technology infrastructure; existing technologies within the environment; and the structure of the built environment, including the placement and structure of such things as buildings, labs, and offices.
- **Use-related factors** are those factors related to the specific uses made of the innovation and the way these uses impact and are impacted by the context(s) of use. These factors include, but are not limited to, actual use(s) of the innovation,

including whether such use represents full or partial adoption; the role of the innovation in the context of specific work and workflows; the observability of results of use; the specific impacts of use on individual and organizational goals and outcomes; and whether or not use is voluntary.

Human values are expected to play a role in adoption decisions in all four of these quadrants. The values that informed the design of the innovation, the values of individual adopters, the values of social groups and organizations, and the ways values and value systems interact in specific use contexts are all expected to influence adoption decisions.

As this is an exploratory study, the semi-transparent dark cloud in the center represents potential other or unknown factors not previously considered that may be uncovered in the course of the research and found to impact adoption decisions for interactive innovations in research-intensive health care environments.

Research Environment and Study Population

The exploratory study used a two-phase mixed-methods approach to examine the adoption of two different interactive innovations recently introduced at a large academic medical center located in the southern United States. The medical center meets the definition of a research-intensive environment with multiple primary missions: patient care, medical education, and research. Within this environment, adoption decisions were studied at the micro level, or level of the individual end user. The research examined adoption decisions at the individual, not organizational, level as innovation adoption was not universally mandated by the organization itself, though

individual perceptions of the voluntariness of adoption decisions vary, as will be discussed in Section 4. The study population consisted of physicians in training, the 228 medical residents and fellows enrolled at the graduate school of medicine. Studying this single population within the larger environment helped keep some individual and social variables steady while allowing for more in-depth exploration of others.

Innovations Under Study

Research began while two interactive innovations recently introduced to the medical center environment were at an early stage of diffusion. These innovations were the PerfectServe platform for health care communication and collaboration and the I-PASS mnemonic for patient handoffs. A brief description of each innovation is below.

PerfectServe

PerfectServe, or PerfectServe Synchrony, is a commercial health care communication, collaboration, and call management platform (PerfectServe, n.d.). The PerfectServe mobile application allows for text and voice messaging, as well as the sharing of photos or videos on a platform that is compliant with HIPAA regulations on patient privacy and the security of information (see United States Department of Health and Human Services, n.d.). Recent studies have found that smartphone use and use of texting applications are becoming an increasingly accepted methods of communication between physicians, and many believe these methods enhance efficiency in the communication of information and have a positive impact patient care; however, studies have found that not all physicians are necessarily communicating patient information via

secure applications that meet organizational and legal requirements for privacy and information protection (Goldfarb, Kayssi, Devon, Rossos, & Cil, 2016; Ozdalga, Ozdalga, & Ahuja, 2012; Rokadiya, McCaul, Mitchell, & Brennan, 2016; Tran et al., 2014; Wu et al., 2011; Wu et al., 2013). In May 2016, the Joint Commission, responsible for accrediting health care organizations in the United States, issued guidance allowing for the transmission of patient information via text messaging, so long as the texting is done via a secure platform (Joint Commission, "Update: texting orders," 2016). PerfectServe is one such platform. However, in December of the same year, the Joint Commission clarified that the above guidance did not apply to patient orders; a physician needing to communicate patient care orders would have to do so via another means, such as a verbal phone call (Joint Commission, "Clarification: Use of secure text messaging for patient care orders is not acceptable," 2016). PerfectServe is not just an application for texting. Additional features of PerfectServe include customizable, automated, algorithm-based routing of calls to appropriate on-call team members, caller ID privacy protection, and the ability to send critical-event alerts (PerfectServe, n.d). The customized call routing and secure text messaging features were key parts of the decision to introduce PerfectServe to the medical center, where it was intended to function as a one-size-fits-all communication solution (Epps, 2018). PerfectServe meets the definition of an interactive innovation as it enables multidirectional communication flow via voice, text, and the sending of image files and other electronic data. At the time of the study, participants were required to install the PerfectServe app on their personal smartphones. To learn more about PerfectServe, the researcher saw PerfectServe

demonstrated, met with PerfectServe executives and medical center administrators, and attended meetings of the PerfectServe Council, a group of users from throughout the medical center who meet to discuss ways to improve PerfectServe.

I-PASS

I-PASS is not a commercial application, but a communication process created by and for physicians. It is a verbal mnemonic, meant to standardize communication between residents during transitions in patient care, or handoffs (Starmer et al, 2012). Clear communication during the handoff process is critical for patient safety and continuity of care; one study estimated that over 80 percent of serious medical errors involved miscommunication during patient handoffs (Joint Commission, 2012). As such, multiple mnemonics have been created to standardize communication of critical patient information during the handoff process (see Mardis et al., 2016; Nasarwanji, Badir, & Gurses, 2016). I-PASS was developed by pediatric physicians after they noted the limitations of a previous mnemonic for conveying complex patient information at change of shift (Starmer et al, 2012). The acronym encompasses the following information:

I: Illness severity

P: Patient summary

A: Action list (a to-do list of actions to be taken during the shift)

S: Situation awareness and contingency planning (an if-then plan for events that might happen)

S: Synthesis by receiver

During the synthesis phase, the receiver summarizes the information given by the sender, repeats key action items, and asks questions as needed. Information communicated via I-PASS comes from the patient's electronic medical record. I-PASS meets the definition of an interactive innovation in that it enables—in fact, requires—multidirectional communication flow between sender and receiver. Other hospital environments that have implemented I-PASS have seen an increase in patient safety scores, patient and provider satisfaction, and handoff efficiency (Sheth et al., 2016). The researcher was able to observe multiple demonstrations of the process in action prior to beginning the research.

At the time this research began, it was expected that residents would have experience with using PerfectServe. I-PASS was at an earlier stage of diffusion; residents in some specialties, including Family and Internal Medicine, were using the innovation, while other programs had not yet tried it, or had not yet made the decision to adopt. The study of two innovations deployed in the same location at roughly the same point in time allowed for the comparison of adoption patterns and potential identification of differences in adoption and diffusion resulting from differences in innovation characteristics.

Introduction of Innovations

At the time of the study, both I-PASS and PerfectServe had been recently adopted at the organizational level. One limitation of the study is that the introduction processes for each innovation had already occurred at the time the study began and could not be directly observed. The processes of introducing the innovations into the

environment had been closer to Greenhalgh et al.'s (2005) definition of active dissemination than pure diffusion, as introduction of each innovation had to some extent been planned and managed.

In addition to differences in their characteristics, these innovations also differ in the processes by which they were introduced. The introduction of PerfectServe was largely top down and vendor-driven. The vendor and product were chosen by medical center leadership, and an agreement with the vendor was signed in late 2015. Rollout of PerfectServe in the medical center began with a pilot group in spring of 2016; the majority of users, including residents, were first introduced to the innovation in fall of that year (Epps, 2018; Starnes 2018). This represented PerfectServe's first introduction at an academic medical center (Starnes, 2018). Adoption and full use of the innovation was not mandated throughout the medical center, though use was seen as mandatory for some subgroups. Instead, physicians were required to include and update their contact information in PerfectServe and, if they chose to communicate via text messaging, to do so on PerfectServe's secure platform (Epps, 2018). Individuals and groups were allowed to determine their own call routing algorithms, many of which were changed or simplified after initial rollout when some users or groups found that initial algorithms were impractical or did not account for all potential communication situations (Epps, 2018; Starnes 2018). Initial introduction and training for the innovation was largely handled by the vendor and this training, particularly for nurses, focused extensively on secure text messaging features (Epps, 2018). User feedback on PerfectServe was obtained by the vendor and hospital administration in a number of

ways, including from an initial task force of potential users formed prior to implementation, via a user survey done by PerfectServe, via communication with department leadership, via information technology support personnel, and via the PerfectServe Council, a group of users who, at the time of the study, were regularly meeting to discuss ways to improve PerfectServe (Epps, 2018; Starnes, 2018).

The introduction of I-PASS began at a more local level, with adoption driven to some extent by the Graduate School of Medicine and to some extent by residents themselves. It was originally introduced into the environment by the Assistant Dean for Graduate Medical and Dental Education, following a meeting for accreditors of the (ACGME), where it was presented as one of a variety of verbal handoff tools meeting the ACGME's Clinical Learning Environment Review (CLER) expectations for standardized handoffs (Accreditation Council for Graduate Medical Education, 2014; Metheny, 2018). At the time of the study, diffusion was still ongoing and being largely driven by chosen change agents, in particular voluntary early adopters from the institution's Chief Resident Council, following the eight change management steps outlined by John Kotter (2012). Kotter's (2012) eight steps for organizational transformation were followed by the team that developed I-PASS in its initial introduction and are popular in health organization management literature, though the model as a whole has yet to be independently tested and verified in empirical research (Appelbaum et al. 2012; Kotter, 2012; Starmer et al., 2014). Some of the steps have potential parallels with factors in Rogers' diffusion model and/or the PMIIA. Step one, "Establishing a sense of urgency" relates to establishing the relative advantage of the

change over the status quo, while Step 2, "Forming a powerful guiding coalition" involves identifying and persuading individuals who act as opinion leaders within the organization (Kotter, 2012; Rogers, 2003). Step 3, "Creating a vision" and Step 4, "Communicating the vision" again relate to communicating the relative advantage of the change, as well as the change's compatibility with the existing environment, while Step 5, "Empowering others to act on the vision" relates to dealing with environmental factors that represent barriers to adoption. Step 6, "Planning for and creating short-term wins" could in some cases be related to innovation trialability. Steps 7 and 8, "Consolidating improvements and producing still more change" and "Institutionalizing new approaches" involve establishing new cultural norms in the final stages of diffusion (Kotter, 2012; Rogers, 2003). I-PASS was communicated to resident groups by chief residents, program directors, and the Graduate Medical Education Council (GMEC), and the assistant dean personally observed multiple handoffs by groups using the I-PASS tool to determine that it was effective and to gather feedback (Metheny, 2018). At the time the study took place, adoption of I-PASS, like adoption of PerfectServe, had not been universally mandated, though adoption was seen as mandatory by some subgroups.

Phase 1: Interviews

Phase 1 of the research consisted of a series of semi-structured qualitative interviews with a snowball sample of physicians in training who were current or potential users of at least one of the innovations in the study. The goal of this phase was to collect in-depth data on how respondents are using the innovations, the roles they perceive for the innovations in their work practices and work lives, and how respondents

discuss the innovations with others. It was also expected that this phase would yield rich data on factors related to adoption that may be difficult to quantitatively measure and would potentially uncover information about unknown factors not included in the model. Further, this phase of the research was expected yield data about the values respondents referenced and the specific vocabulary respondents use when discussing the innovations.

Initial potential participants were identified by faculty and chief residents in the graduate school of medicine who were asked to forward an initial recruitment email inviting individuals' participation in the study. Those who contacted the researcher expressing interest in participating were contacted again to schedule an interview at a time and location of the participant's choosing. As residents and fellows have demanding schedules, this could be at any time of day or night, though most took place during daylight hours; the earliest at 6:30 a.m. and the latest at 5:15 p.m. Interviewees signed an informed consent statement prior to the interview. Participants were free to not answer any question and were free to exit the interview at any time. Participants were given a $10 Starbucks gift card as a thank you for their time. In total, seven participants were recruited for this phase of the study (Table 1). Recruitment continued until data saturation was deemed to have been achieved, based on redundancies in the collected responses (Saunders et al., 2018).

Interview questions were asked about respondents' work, their current and past use of each innovation, their perceptions of each innovation, problems encountered during use of the innovations, and with whom they had discussed each innovation.

Table 1. Phase 1 study participants by specialty.

Interview	Specialty
1	Fellow, Pulmonary Disease and Critical Care Medicine
2	Fellow, Pulmonary Disease and Critical Care Medicine
3	Fellow, Pulmonary Disease and Critical Care Medicine
4	Second Year Resident, Surgery
5	First Year Resident, Internal Medicine
6	First Year Resident, Family Medicine
7	First Year Resident, Oral & Maxillofacial Surgery

Interviews varied in length depending on participants' responses and were between approximately sixteen and forty-two minutes long. Depending on responses, the interviewer asked follow-up questions and additional questions for clarification as needed. A copy of the interview guide is reproduced here as Appendix A. Interviews were recorded with participants' permission. Once completed, each interview was transcribed from the recording by the researcher. Transcripts were between eleven and twenty single-spaced pages. Interviews were coded utilizing the software package NVivo. Content analysis was conducted to identify broad themes and specific vocabulary used by respondents when discussing the innovations. As this phase of the research was largely exploratory, an initial round of open coding, informed by the diffusion of innovation model and the conceptual categories of the PMIIA, was conducted to identify themes and categories emerging from the data. A second round of focused coding was performed to in order to refine and establish links between categories. From this phase of coding, a codebook was developed and a second coder was recruited. This coder had an academic background in communication and information and a family background in medicine, though was not familiar with diffusion of innovations research. Following a third phase of coding, coders consulted and the codebook was further refined, before a final phase of coding was conducted. Inter-coder reliability between the two coders as calculated in NVivo using weighted Cohen's Kappa at the character level was .5, considered a moderate level of agreement (Landis & Koch, 1997), with percent agreement for each node between 93.5 and 100 percent.

Phase 2: Survey

Phase two of the research consisted of an online survey of the entire population to gather quantitative data on actual use of PerfectServe and I-PASS and data on each of the following:

- User demographic variables potentially related to adoption, including age, gender, residency or fellowship program, and year in the program;
- Personal innovativeness. Questions for this part of the survey were adapted from the Personal Innovativeness in Information Technology Scale (PIIT) developed and tested by Agarwal & Prasad (1998);
- For each innovation, questions related to the individual's knowledge of the innovation;
- For each innovation for which the individual reported having knowledge, questions related to the individual's use of the innovation;
- For each innovation the individual had used:
    - Questions related to the innovation itself, including questions related to its ease of use, trialability, and compatibility;
    - Questions related to social and environmental factors impacting adoption of the innovation, including visible use of the innovation by others, communication norms and practices, the availability of training, and compatibility with organizational policies;

- Questions related to use, including actual use, perceived voluntariness of use, the ability to customize the innovation use, and observability of impact.

Many questions in final four sections in survey were adapted from the instrument designed and tested by Moore & Benbasat (1991) to measure perceptions of adopting an information technology innovation. Questions involved statements with which the user could express agreement on a five-point Likert-type scale (1 = Strongly Disagree; 5 = Strongly Agree). In some cases, wording of statements from existing items from the Moore & Benbasat (1991) instrument had to be slightly altered for I-PASS, which is an information tool, but not strictly a technology (Rogers, 1986). Additionally, respondents who had used each innovation were given a free form text field to provide additional feedback about the innovation. Results from Phase 1 helped informed question choice and wording for development of the survey instrument. A draft version of the survey was reviewed by faculty members in the Graduate School of Medicine and the College of Communication and Information (CCI) and tested by CCI students prior to distribution to the study population and revised based on their recommendations.

The survey was conducted online using the Qualtrics survey software program hosted by the Office of Information Technology at the University of Tennessee. As Likert-types items were bundled, the full survey instrument contained 35 total questions as measured by Qualtrics, or 107 individual items. Skip logic was used so that survey respondents would not be asked further questions about an innovation with which they were unfamiliar, would not be asked about their experiences with an innovation they

had not tried, and would not be asked about organizational policies related to an innovation if they had previously answered that such policies did not exist or that they were uncertain about the existence of such policies. As such, survey response time was expected to take between 10-20 minutes but varied depending on respondents' answers. A copy of the full survey is included here as Appendix B.

An invitation with a link to the survey was distributed via email to all residents and fellows at the graduate school of medicine. All members of the study population had an institutional email address and could be reached via this method. Those who clicked the link to take the survey were presented with an informed consent statement, and by proceeding to the survey, acknowledged that they were over 18 and agreed to participate. Per IRB requirements, respondents were allowed to skip any question. As reminders have been shown to increase survey response rates (see Cook et al., 2016; Cunningham et al., 2015; Dykema, Jones, Piché, & Stevenson, 2013), a reminder email was sent to all potential participants each week the survey was open. Survey data collection began October 5, 2017 and concluded November 30, 2017. Those who received the invitation to participate had an opportunity to enter a drawing to win one of two $25 Starbucks gift cards. Ability to enter the drawing and chance of winning were not dependent on participation in the survey. Two winners were selected via random drawing following the conclusion of the survey. Interested participants could also leave information to be contacted for a follow-up interview for a third phase of the study. Contact information for the gift card drawing and for follow-up interviews was collected via a separate form and was not linked to survey responses.

The survey received fifty-two responses. Following data cleanup, forty-one usable responses in which the respondent had answered at least one of the questions related to innovation diffusion were retained for further analysis, for a response rate of 18%. Survey completion rate as measured by Qualtrics was 70.7%, though because skip logic was used and respondents could opt not to provide an answer to any question, some surveys measured as complete have some level of item non-response. The low survey response rate is one of the limitations of this study and limited the statistical analyses that could be performed with the data, including the ability to run regression analyses. To some extent, a low response rate was anticipated, as low response rates are common in surveys of physicians, and while web-based surveys do represent a convenience to users, are less expensive to implement than paper surveys, and often result in more complete data, some studies have found that their response rates are up to 10% lower than other survey methods, such as postal mail and fax (see Cook et al., 2016; Cunningham et al., 2015; Dykema et al., 2013; Grava-Gubins & Scott, 2008; Kellerman & Herold, 2001; Scott et al., 2011). A review of the literature found that for web-based surveys of physicians, reported response rates of less than 20%, as in the present study, are not uncommon (Dykema et al., 2013).

An additional study limitation is that it is difficult to determine non-response bias and make meaningful comparisons between the survey respondents and the study population as a whole, as almost a third of respondents (31.7%) did not answer demographic questions related to their specialty or program year (Tables 2 and 3). This may be because respondents were reluctant to provide potentially identifying

Table 2. Reported specialties of survey respondents.

Specialty	Valid Responses (n = 28)*
Internal Medicine	6 (21.4%)
Family Medicine	5 (17.9%)
General Surgery	5 (17.9%)
Pathology	3 (10.7%)
Anesthesiology	3 (10.7%)
Oral & Maxillofacial Surgery	2 (7.1%)
Radiology	2 (7.1%)
Pulmonary Disease and Critical Care Medicine	1 (3.6%)
Transitional Year	1 (3.6%)

*31.7% did not provide a valid response

Table 3. Responses by program year.

Year in Program	Valid Responses (n =28)*
1	15 (53.6%)
2	4 (14.3%)
3	6 (21.4%)
4	2 (7.1%)
5	1 (3.6%)

*31.7% did not provide a valid response

information, or it may be due to survey fatigue, as demographic questions were located at the end of the survey (see Dillman, Smyth, & Christian, 2014).

Among those who did answer demographic questions, there were notable differences from the population as a whole, particularly in the lack of identified responses from those specializing in Obstetrics and Gynecology, Urology, or any specialty with six or fewer total residents or fellows. Among those who did provide their specialty, Family Medicine, General Surgery, Internal Medicine, Oral & Maxillofacial Surgery, and Pathology are somewhat overrepresented as compared to the population as a whole, and Anesthesiology and Radiology somewhat underrepresented. Among those who reported their program year or level, those in their first year were overrepresented. Those in most later years are, with the exception of year three, underrepresented (Table 3).

Respondents were also asked for their birth year and gender. The ages of those respondents who did answer the question about year of birth (n =26, 63.4%) ranged from 26-41 years, with a mean age of 30.3 (SD = 3.4). This small age range is perhaps unsurprising given that these respondents are at a similar stage of their education and career. Table 4 shows responses to the question about gender.

Following closure of the survey, responses were downloaded and analyzed using IBM SPSS Statistics software. Results of the analysis will be discussed in Section 4.

Protection of Human Subjects

At each stage of the research process, the appropriate approval was obtained from the University of Tennessee Institutional Review Board (IRB) in

Table 4. Participants' reported gender.

Gender	Valid Responses (n =27)*
Female	9 (33.63%)
Male	17 (63%)
Other	1 (3.7%)

*34.1% did not provide a valid response

coordination with IRB personnel at the medical center to ensure research was conducted appropriately and in accordance with protocols at both institutions. All electronic records resulting from the research were stored on University of Tennessee servers and/or password protected computers and were accessible only to research personnel. Physical records resulting from the research were stored separately, under lock and key, and accessible only to research personnel.

Risks to human subjects as a result of this research were minimal, and no more than might be encountered in everyday life. All participants were over 18 and signed or electronically agreed to an informed consent statement prior to participating in any part of the research. No Protected Health Information (PHI) was collected or retained as part of the study. The researcher took required training on HIPAA compliance and the protection of any patient information that may have been encountered as a result of being on-site on the medical center campus.

Limitations

In addition to the limitations resulting from survey response rate discussed above, there are other noted limitations to the research. The research only examined the diffusion of two interactive innovations among a single group of practitioners within a single organization. Future research will better determine whether the tools developed in this research can be applied at other types of health care organizations and potentially at research-intensive organizations with other specialties.

The initial study was conducted with two innovations that were at an early stage of diffusion, but that had already been adopted at the organizational level and

introduced into the environment. While the results of this study may inform how future innovations are initially developed, introduced, and communicated, as noted previously, observation of these early phases could not be part of this research, and therefore variables related to the specific processes of development—particularly if development involves end-users directly—and initial deployment may have been missed (Ash, 1997; Berg, 2001; Berwick, 2003). The fact that in each case, use of the innovation was seen as mandatory by some respondents impacted results, and adoption patterns found here likely differ from those that would be found if adoption was entirely voluntary.

Finally, this research examines adoption and diffusion only during a particular period of time. This may or may not be enough time for the innovations to have fully been diffused among the intended user communities or for confirmation of initial decisions to adopt or reject the innovations to occur. A third phase of the planned research, involving follow-up interviews to gain additional insights on data gathered during the first two phases and collect information on developments in the innovations and their diffusion since the initial interviews has not yet been completed at the time of this writing due to delays in obtaining IRB approval for this phase of the research. Consequently, the full impact of network externalities and the reciprocal interdependence of earlier and later adopters may not be picked up by the research design and may require follow-up study after more time has passed. A follow-up study with a social network analysis component might also reveal whether changes have occurred in the shape or size of the network in later stages of diffusion of these innovations, though not specifically whether this can be attributed to the innovations

themselves. A further consideration related to time is that residents have a fixed time in the program; as residents leave the program, the size and shape of the social network will inevitably change. This research can potentially point to current opinion leaders, but not necessarily to which members of the network will have this type of influence in the future.

CHAPTER FOUR
RESULTS

This chapter gives a brief overview of the current state of diffusion and adoption of each innovation at the time of the Phase 2 survey. It then revisits the research questions and answers that were obtained from both phases of the study.

Diffusion and Adoption of PerfectServe and I-PASS: An Overview

PerfectServe

It was expected that all members of the population under study would have some awareness of PerfectServe, and this was substantiated by Phase 2 survey results. Of the 41 individuals who answered the question "Have you ever heard about PerfectServe?", 97.6% answered that they had heard about the innovation (Figure 2).

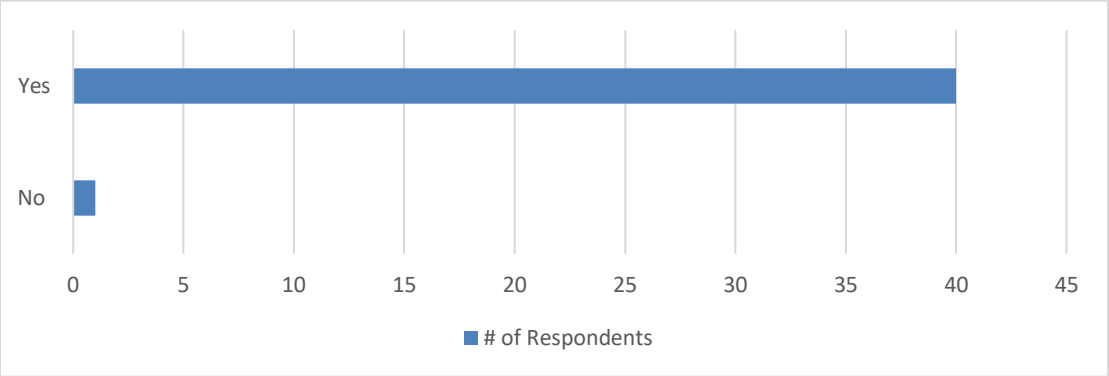


Figure 2. Have you ever heard about PerfectServe?

Results of the quantitative survey also showed adoption of PerfectServe was not universal. Of the 40 users who had heard of the innovation, all but one answered the follow-up question "Do you currently use PerfectServe?" The large majority, 84.6%, stated they currently use PerfectServe; 5.1% indicated they do not use PerfectServe, but have in the past; and 10.3% stated they had never used PerfectServe (Figure 3).

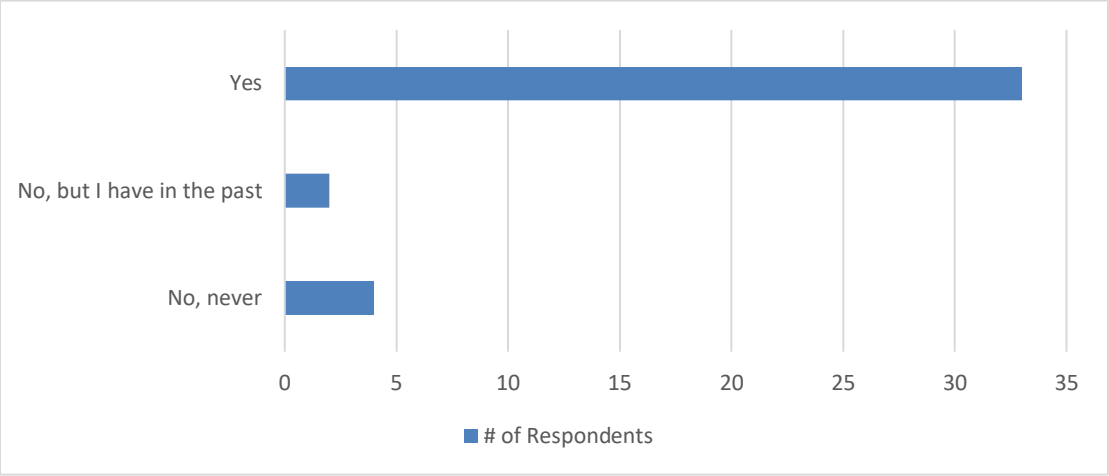


Figure 3. Do you currently use PerfectServe?

I-PASS

As I-PASS was at an earlier stage of diffusion at the time of the study, it was expected that not all respondents would be aware of I-PASS, and this was substantiated. Of the thirty-one individuals who answered the question "Have you ever heard about I-PASS?", 61.3% had heard about it, while 38.7% had not (Figure 4).

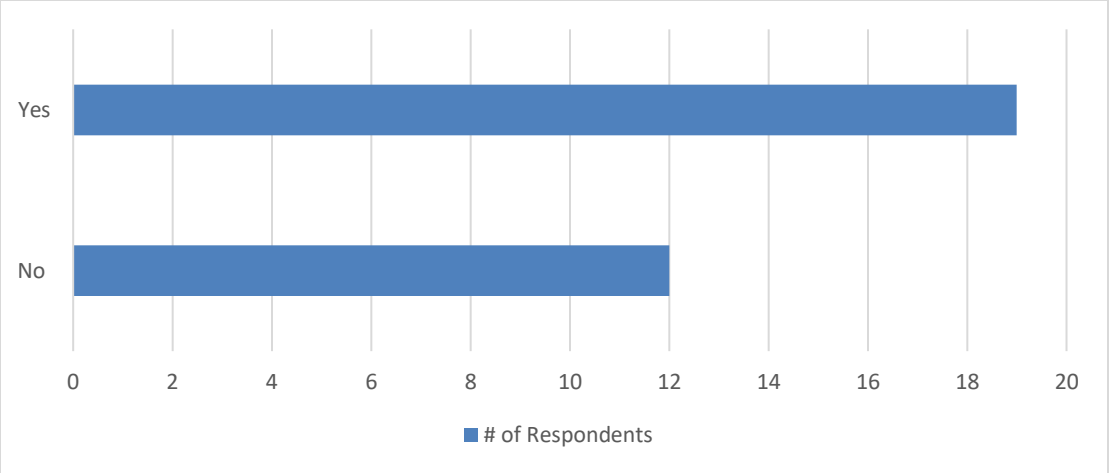


Figure 4. Have you ever heard about I-PASS?

Of those who had heard about I-PASS, 42.1% stated that they currently use the procedure; 36.8% do not but have in the past; 10.5% have never used it; and 10.5% responded they were not sure (Figure 5).

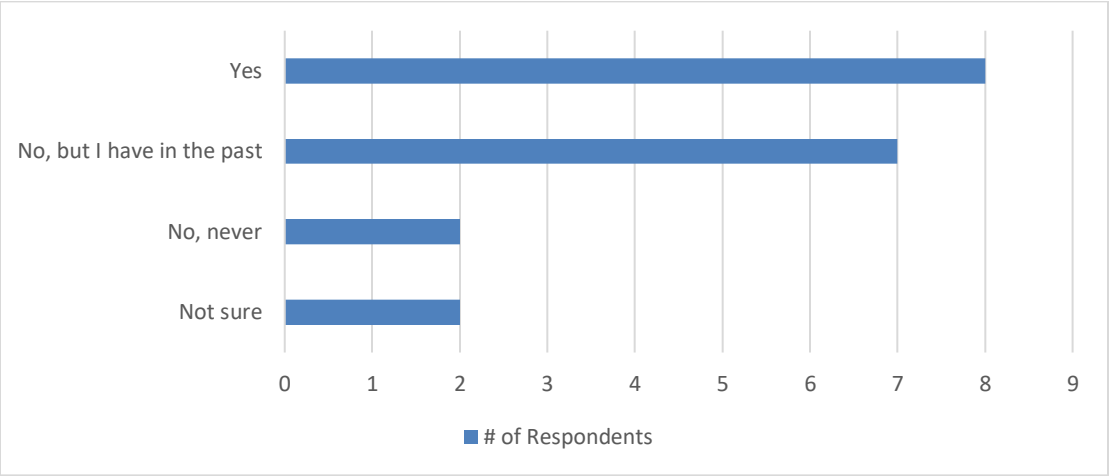


Figure 5. Do you currently use the I-PASS handoff procedure?

Differences in perceptions of the innovation between those in the survey who had adopted I-PASS, here referred to as *adopters*, and those who had used the innovation, but were not current users, here referred to as *non-adopters*, provide some useful data for comparison.

The following sections revisit the research questions and report results from both phases of the study in order to answer those questions and present a detailed picture of adoption of interactive innovations within the study environment.

Factors Related to Adoption of Innovations in Research-Intensive Health Care Environments

RQ1: What factors influence adoption of innovations for information sharing and communication in research-intensive health care environments?

RQ2: Which factors have the most impact on the probability of adoption of an interactive innovation by target users?

Factors from each quadrant of the PMIIA were found to impact users' adoption decisions and/or perceptions of the innovations (Figure 6). No additional categories of factors impacting adoption were observed, thus the cloud representing 'Other/Unknown Factors' has been removed from this revised version of the model, though the study did point to the importance of understanding the interactions between factors, as well as the importance of considering conditions, contexts, and power structures that may lead certain actors within the system and categories of factors to have greater or lesser influence on adoption decisions, which will be discussed in later sections. This section revisits the study results in detail by quadrant.

Innovation Factors

Innovation factors are those related directly to the innovation itself. A number of these factors were mentioned by individuals in the Phase 1 interviews and asked about directly in the Phase 2 survey.

Ease of Use: "It's Not Difficult to Use, when it Works"

Ease of use is here defined as the opposite of Rogers' (2003) complexity; the degree to which an innovation is seen as easy to understand and use.

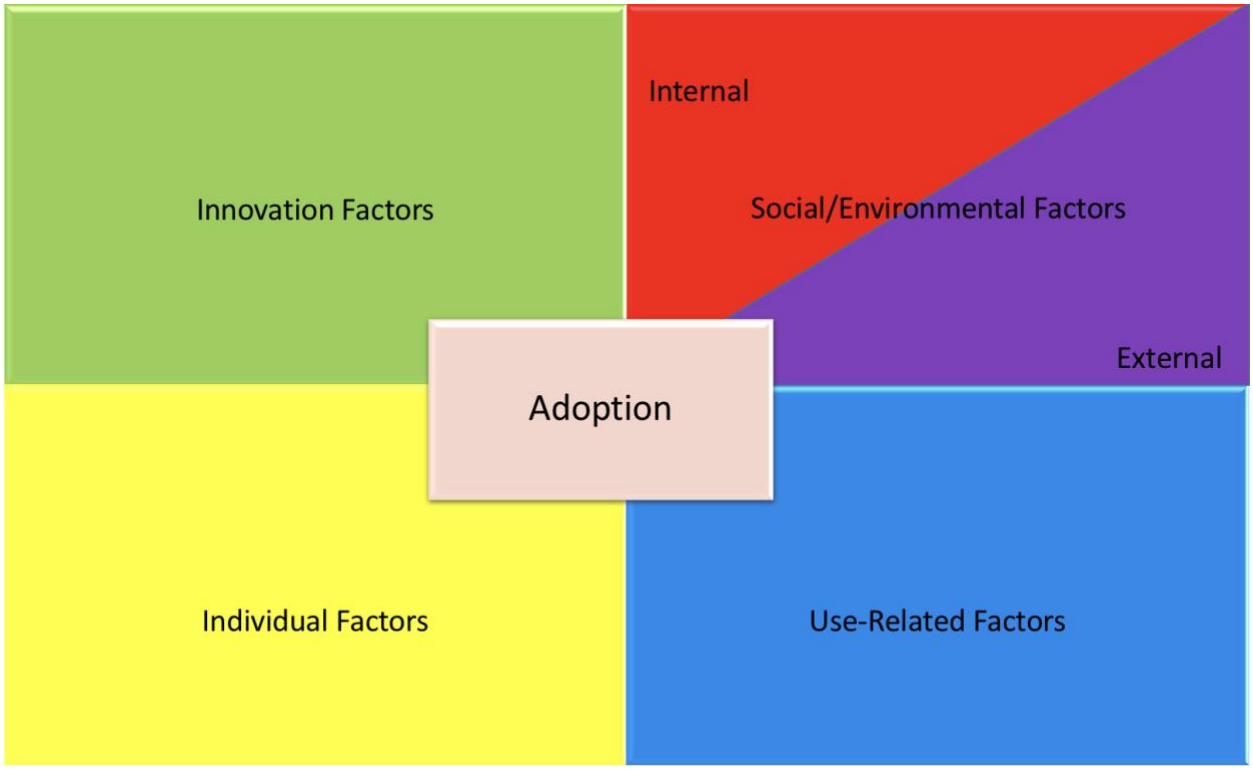


Figure 6. The Pollock Model of Interactive Innovation Adoption (PMIIA) revised.

PerfectServe.

The majority of respondents in the Phase 2 survey who had used PeferctServe agreed that it was easy to use (Table 5). Respondents were more divided in their responses to the statement *It is easy to get PerfectServe to do what I want it to do*, with mean levels of agreement near the midpoint.

The Phase 1 survey results provided some additional context for these answers. According to one respondent, "it's not that difficult to use, when it works" (Interview 1). When PerfectServe was perceived as not working, it was often due to technical problems, or difficulties performing specific tasks.

Bugs and errors.

A number of technical issues, bugs, and errors were identified by users of PerfectServe, including:

- Problems with launching and loading the application
- Problems logging on
- Application crashes and freezes
- Missed or delayed messages
- Wireless connectivity issues (to be discussed further in the section on social and environmental factors).

Additionally, problems with misdirected messages, messages not forwarding appropriately, or residents and fellows receiving PerfectServe messages at inappropriate times were noted by multiple respondents, though whether this was human or system error was not always clear.

Table 5. Assessments of ease of use for PerfectServe.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
It is easy to get PerfectServe to do what I want it to do.	Y (33)	3.06	1.3	45.4%	18.2%	36.4%	0.58
	N (2)	2.5	2.12	50%	0	50%	
Overall, PerfectServe is easy to use.	Y (33)	3.67	1.08	60.6%	24.2%	15.1%	1.42
	N (2)	2.5	2.12	50%	0	50%	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

> There were a lot of difficulties with people getting paged at inappropriate times and, you know, people, you know, once you leave the hospital, getting paged about patients when it should be somebody who's coming on to start covering those patients (Interview 5).

The potential negative impact on patient care was noted:

> my upper-levels were having a lot of issues where the, the calls and pages weren't forwarding the way they were supposed to…that could have gotten dangerous. Luckily, nothing bad happened. But there was definitely a little bit of bumpy road in the beginning (Interview 6).

Some respondents viewed this "bumpy road" as a natural consequence of standing up a new technology in a new environment: "Probably everything's just kind of hard at the beginning. You have one way of doing things for I don't know how many years before I got here, and suddenly it's different" (Interview 6) and/or acknowledged that these issues had improved with time: "it took 'em three or four months just to work out all those nuts and bolts, but they did" (Interview 1). However, the nature of the work in the hospital environment meant that respondents could afford to be less forgiving of errors, either technical or human:

> I mean, the thing is, PerfectServe isn't bad, it's just, I've had a lot, like we've had a lot of bad issues, which has, I think, probably tainted my view of it somewhat, because, you know, there are gonna be bugs and kinks when new systems roll out. It's just harder to get that sour taste out of your mouth when it deals with

patient care, and it's like, these patient issues that need to be dealt with, um…in more sensitive ways (Interview 4).

One respondent noted that these issues had the potential to constrain communication, stating: “[PerfectServe] makes you almost not want communicate with somebody” (Interview 1).

Difficult menus.

Additionally, over half the Phase 1 respondents noted that they found PerfectServe's menu structures difficult or cumbersome to use at times, which contributed to their frustration with the innovation. This could be exacerbated by the fact that not all physicians within the hospital were users of PerfectServe, something that was not immediately obvious to those attempting to contact them.

> [S]ometimes people get around wanting to be PerfectServed. Like it'll try to pick somebody, and if it's like a group practice or the ICU or whatnot, it might say, "Oh, are you contacting about, um, a consult or an existing patient?" And it's like okay, a new consult. Are you, is this a patient we see in clinic or whatever? And you'll go through this big checklist and it'll say, "Actually, this person's covering." You have to go out and then start all over with the new person. And sometimes it's almost like a loop. Or it'll say, "This person prefers to be contacted by email, and I'm like, "If I had some way to contact them in the hospital right now, I would, but that's why I was using PerfectServe." Um…but other than that, it's simple. If you actually pick someone and it just pops up, there's just a message there, and

you just type it and say send. Or you attach a picture and send it off. So that's, that's fairly straightforward. (Interview 6).

I-PASS.

For the purposes of describing the results of this research, those respondents who currently use the innovation are referred to here as *adopters* and those who no longer use the innovation are described as *non-adopters*. A statistically significant difference ($p < .05$) was found between adopters and non-adopters of I-PASS in the Phase 2 survey. All users of I-PASS agreed to some extent that I-PASS was easy to use, while over two-thirds of those who did not use the innovation neither agreed nor disagreed with this statement (Table 6).

Table 6. Assessment of ease of use for I-PASS.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
Overall, I-PASS is easy to use.	Y (8)	4.38	0.52	100%	0	0	2.42*
	N (6)	3.5	0.84	33.4%	66.7%	0	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

In the Phase 1 interviews, one respondent who was currently using I-PASS noted "since we transitioned it's been relatively easy. Especially since it was so similar [to the previous handoff procedure], it wasn't that big of a change" (Interview 6). Those in the interviews who did not adopt I-PASS did not cite difficulty in using I-PASS as a reason for the lack of adoption, but were instead likely to mention other factors, including the time it took to use I-PASS and preference for locally developed handoff procedures.

Innovation Features: "It's Nice When I Can Get Pictures of Things"

In the case of PerfectServe, users mentioned particular features that contributed to their positive or negative experiences with using the innovation. Aside from its capabilities for texting, features mentioned by PerfectServe users as those they particularly liked or found beneficial include:

- Ability to send images
- Ability to look people up by name/directory of all the physicians that use PerfectServe
- Ability to tell when messages were seen by others
- Security features (to be discussed in more detail later in this chapter).

By contrast, there were features of PerfectServe that users found difficult or frustrating, including its menus. At least one user attributed this frustration to assumptions made by the innovation, in which call management features meant to help the user instead added additional, unnecessary steps to the user's workflow: "I think it, it assumes that you don't know who the right person [to contact] is at the time, so it tries to help facilitate that, getting you that information, but oftentimes, you know who that right

person is. You don't want to have to go through all those hoops every time; you'd just rather be able to call that person directly" (Interview 1).

Additionally, message reminder features frustrated users. If a user fails to respond to a PerfectServe message, the system is set up to send text reminders, followed by a phone call, followed by a reminder via pager. "So, it sends you, I believe it sends two texts…'This is just a reminder to answer a PerfectServe message.' After two texts, a few more minutes later it gives you a ring…And then the pager is connected to this and this starts going off. Um, I've had a problem with that when it goes off at 6:00 a.m. and I, it's woken up my household" (Interview 2). Inability to shut off reminders when one was unavailable by phone, such as when the respondent was in the operating room, and inability to tell if messages were urgent sometimes added to user frustrations with message reminders.

Some features were experienced differently by different users. For example, PerfectServe's ability to retain messages and to allow users to review previous conversations was seen as a positive feature by two users in the Phase 1 surveys but was one user's least favorite feature and seen as incompatible with the nature of the communication platform, particularly as these messages could be retained for legal purposes: "[I]t's a very, uh, willy-nilly sort of platform to be a legal, binding document, I guess I would say. If that makes sense…[Y]ou would never write a note, or do a progress note for a patient that feels willy-nilly, but it's very easy to communicate on a, essentially a texting platform, willy-nilly. Or use short, short term, short language. I

mean that, so it all, all those things make, kind of just make you a little leery about how you're communicating" (Interview 5).

Interviewees were also asked about what their ideal communications platform would look like. Some named additional features including the ability to easily see the name of the physician on call and to have pager numbers listed in PerfectServe.

Relative Advantage: "I'd Rather Just Make a Phone Call"

The innovations' relative advantage, or lack thereof, over existing information technologies and processes in the environment were mentioned several times throughout the Phase 1 interviews.

PerfectServe.

The HIPAA-compliant security of PerfectServe gave it a relative advantage over other types of text messaging. One user also noted a privacy and security advantage over making a phone call, "which works but is inconvenient and sometimes it's hard to find an isolated enough area to communicate securely if you're talking about patient care" (Interview 6). However, some users found that face-to-face or phone communication provided an advantage over PerfectServe for conveying certain types of information, such as difficult patient issues: "I'd much rather be face-to-face or talking over the phone, because then I feel like I could get a better picture of what's going on. It's more difficult to elucidate the whole picture on, you know, a text message, um, for these, for difficult patients" (Interview 4). Others felt that PerfectServe took more time or added additional steps to their workflow in contrast to making a call. "[W]hen time is of the essence, PerfectServe is not my first choice, just because of how arduous it is…I'd

rather just make a phone call at that point" (Interview 1). Respondents' opinions on the relative advantage of PefectServe over the numeric or alphanumeric pager system varied. For urgent communication, some users strongly preferred to be paged. "[I]t would also be nice if when a nurse goes to page us, or goes to send us a message through PerfectServe, if they first had to answer [a] question, 'Is this urgent or not?' If it's urgent, I'd rather be paged and have my pager number display there" (Interview 7).

I-PASS.

Non-adoption of I-PASS was linked by respondents to a lack of relative advantage over existing, locally developed handoff procedures. "At least at our facility and within my residency program, every[one] gives a, a good enough checkout where standardizing it wouldn't increase the quality" (Interview 5). In at least one case, it was seen as the same as the respondent's existing handoff process: "I remember a couple of months ago, it was talked about and then we looked at it and we realized it's what we're doing" (Interview 7), though further questions revealed the local process lacked the I-PASS synthesis phase. Some felt that switching to I-PASS would represent a disadvantage relative to local procedures, because of the length of time I-PASS was expected to take. "If we had to I-PASS every single one of our surgery patients, we would be here for four hours. Our, our handoffs are roughly thirty minutes" (Interview 4).

Trialability: "I Was Told, 'This is PerfectServe. We're Gonna Use It. Have Fun.'"

Trialability refers to the degree to which an innovation may be experimented with on a limited basis (Rogers, 2003). Trialability may be limited by the nature of an

innovation, or it may be limited by such things as organizational requirements and the voluntariness of use.

PerfectServe.

In the Phase 2 survey, respondents had low levels of agreement with statements related to being able to try PerfectServe before committing to using it (Table 7). Either because of the technological investment required or because use was not voluntary for all user groups, there may have been little chance to experiment with the innovation before being required to adopt it. In the words of one interviewee, "I was told, 'This is PerfectServe. We're gonna use it. Have fun.'" (Interview 5).

I-PASS.

Mean levels of agreement on similar statements concerning the trialability of I-PASS were somewhat higher than for PerfectServe (Table 8). As an information process, I-PASS does not require an up-front technological investment, which may have contributed to this difference.

Compatibility: A Significant Factor for I-PASS

Survey respondents were asked their levels of agreement with statements related to the compatibility of innovations with users' work and communication needs, work styles, and work environments.

PerfectServe.

Assessments of PerfectServe on these measures of compatibility showed that opinions were divided, though a majority of participants did agree on every item (Table 9).

Table 7. Assessments of trialability of PerfectServe.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
Before using PerfectServe, I was able to try it out.	Y (31)	1.71	1.19	12.9%	9.7%	77.4%	-0.33
	N (2)	2	1.41	0	50%	50%	
I was permitted to use PerfectServe on a trial basis long enough to see what it could do.	Y (31)	1.61	1.05	9.7%	12.9%	77.5%	-0.5
	N (2)	2	1.41	0	50%	50%	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Table 8. Assessments of trialability of I-PASS.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
Before using I-PASS, I was able to try it out.	Y (7)	2.14	1.21	14.3%	28.6%	57.2%	-1.43
	N (6)	3	0.89	33.3%	33.3%	33.3%	
I was permitted to use I-PASS on a trial basis long enough to see what it could do.	Y (7)	2.29	1.38	28.6%	14.3%	57.2%	-1.46
	N (6)	3.17	0.75	33.3%	50%	16.7%	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Table 9. Assessments of compatibility for PerfectServe.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
PerfectServe is compatible with my work and communication needs.	Y (33)	3.58	1.35	69.7%	0	30.3%	1.07
	N (2)	3.45	1.52	50%	0	50%	
PerfectServe fits well with the way I like to communicate.	Y (33)	3.45	1.52	66.7%	0	33.4%	0.85
	N (2)	2.5	2.12	50%	0	50%	
PerfectServe fits well into my work style.	Y (33)	3.06	1.3	57.6%	12.1%	30.3%	0.89
	N (2)	2.5	2.12	50%	0	50%	
PerfectServe makes sense for the environment in which I work	Y (33)	3.39	1.41	60.6%	9.1%	30.3%	0.85
	N (2)	2.5	2.12	50%	0	50%	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

I-PASS.

I-PASS adopters had significantly higher levels of agreement than non-adopters that I-PASS was compatible with their own work and communication needs, the way they like to communicate, and their work style (Table 10).

Table 10. Assessments of compatibility for I-PASS.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
I-PASS is compatible with my work and communication needs.	Y (8)	4.25	0.71	87.5%	12.5%	0	2.25*
	N (6)	3.33	0.82	50%	33.3%	16.7%	
I-PASS fits well with the way I like to communicate.	Y (8)	4.13	0.99	87.5%	0	12.5%	2.24*
	N (6)	2.83	1.17	33.3%	33.3%	33.4%	
I-PASS fits well into my work style.	Y (8)	4.25	0.71	87.5%	12.5%	0	3.61*
	N (6)	2.83	0.75	16.7%	50%	33.3%	
I-PASS makes sense for the environment in which I work.	Y (8)	4.13	0.99	87.5%	0	12.5%	1.97
	N (6)	3.17	0.75	33.3%	50%	16.7%	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Compatibility is an innovation characteristic important to diffusion studies, but it is not a fixed quality, nor is it one inherent to an innovation. Determining compatibility requires consideration of individual adopters, the environment in which adoption takes

place, and the uses to which innovations will be put. Concepts related to compatibility will be discussed further in later sections.

Individual Factors

Individual factors are those related to an individual capable of making adoption decisions. As adoption was studied here at the level of individual persons, individual factors of interest include demographic factors such as age, gender, and specialty; personal innovativeness; prior experience with the same or similar innovations; and personal communication preferences. In the Phase 2 survey, there were no interactions found between the demographic variables of age, gender, and specialty.

Age or Generation: "I Think There's Always a Barrier to People Who Are Older"

In Phase 1 interviews, age was hypothesized to be a potential barrier to adoption, particularly for older physicians in regards to PerfectServe. Said one respondent, "I think there's always a barrier to people who are older, who are not used to technology" (Interview 3). Said another, "especially for some of the older physicians that are maybe not as technologically savvy, I think that they are completely against PerfectServe because of, it's new and they only want to be contacted with their pager" (Interview 4). However, an earlier comment by the same interviewee established that while they felt their membership in their particular generational group made them more personally more comfortable with texting in general, it did not impact their communication preferences when it came to issues of patient care. "I am of this, like,

technologically-advanced generation. Like, I like texting. I frequently text. I pretty much only text, um, until I have to deal with acute patient issues" (Interview 4).

As noted in Section 3, the age range from the youngest to oldest respondent who reported their birth year in the Phase 2 survey was fifteen years. To determine if age, and potentially early experience with technology, impacted adoption decisions, birth year was recoded into a generational variable: a group of those born in 1985 or after, hereby referred to as Millennials, and a group of those born prior to 1985, which encompasses both Generation X and the Xennials, a term that has emerged recently in business literature to describe a "micro-generation" between Generation X and Millennials, distinguished from Millennials by their early experiences with information technology, in particular the fact that the Internet and social media were not part of their childhood (Taylor, 2018). While this, like all generational categorizations, involves somewhat indistinct and shifting boundaries, generational differences have been noticed when it comes to communication patterns in the workplace (Taylor, 2018).

In this study, participants did not significantly differ by generation in their adoption of either innovation, in their assessment of their own personal innovativeness, or in their opinions of either innovation, except that Millennials had significantly lower levels of agreement with the statement that many people at the organization use PerfectServe ($M = 4.58$, $SD = 0.61$) than did Generation X/Xennials ($M = 5$, $SD = 0$) ($t(18) = -3.02$, $p < .01$).

Gender: Differences in Assessment, Not Adoption

Gender differences in adoption and use of innovations were not mentioned by any participant in the Phase 1 interviews. Neither was gender was shown to be a predictor of adoption of either innovation in Phase 2. There were no significant differences by gender in Phase 2 participants' assessments of personal innovativeness. While there were no significant differences in adoption of innovations by gender, the Phase 2 results do indicate that participants' experiences of using innovations do vary somewhat by gender.

PerfectServe.

Independent samples t-tests showed some significant differences between female and male respondents in their experiences with PerfectServe (Table 11). Female respondents had significantly stronger levels of disagreement with statements related to the trialability of PerfectServe, their ability to adapt PerfectServe to meet their own work practices and communication needs, and their awareness of others using PerfectServe at other organizations.

I-PASS.

There were also some differences by gender in Phase 2 respondents' reported experiences with I-PASS, though in different assessment categories (Table 12). Female respondents had significantly lower levels of agreement, much nearer the midpoint than male respondents, with statements related to I-PASS's impact on the quality and speed of communication, its impact on their own work, its compatibility with their work and communication needs, the confidentiality of patient information communicated via

Table 11. Differences by gender in assessments of PerfectServe.

	Female		Male		
	M	SD	M	SD	*t*-test
Before using PerfectServe, I was able to try it out.	1	0	2	1.30	-2.15*
I was permitted to use PerfectServe on a trial basis long enough to see what it could do.	1	0	2	1.30	-2.15*
I am able to make changes and adapt PerfectServe to better fit my work practices.	1.63	1.06	2.79	1.42	-2.17*
I am able to make changes and adapt PerfectServe to better meet my own communication needs.	1.75	1.04	2.86	1.35	-2.15*
Many others in my field working at other organizations use PerfectServe.	2.38	0.74	3.29	0.91	-2.54*

**p < .05. M = mean. SD= standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Table 12. Differences by gender in assessments of I-PASS.

	Female		Male		
	M	SD	M	SD	*t*-test
I-PASS enables me to communicate and share information more quickly.	3	0.89	4.2	0.84	-2.3*
I-PASS improves the quality of communication during handoffs.	3	0.89	4.2	0.84	-2.3*
I-PASS makes it easier to do my job.	2.83	0.98	4.2	0.84	-2.49*
I-PASS is compatible with my work and communication needs.	3.33	0.82	4.4	0.55	-2.58*
Patient information shared using I-PASS is private and confidential.	3.33	1.37	4.8	0.45	-2.48*
I-PASS has a positive impact on the quality of communication during handoffs at [this organization].	3.5	0.55	4.4	0.55	-2.71*
I-PASS has improved patient safety.	3.33	0.52	4.2	0.45	-2.98*

**p < .05. M = mean. SD= standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

I-PASS, and its impacts on patient safety and the quality of communication during handoffs.

Program or Specialty: Differences in Adoption, Not Assessment

Of all the demographic variables in the Phase 2 survey, only program or specialty was significantly ($p < .001$) correlated with adoption of either innovation. In fact, adoption was split almost entirely along program lines for those who answered the questions.

PerfectServe.

From survey results, it appears PerfectServe has not been fully diffused among residents and fellows (Table 13). Those pathology and radiology report they have not used it or have discontinued use, while those in other specialties continue to use it. Neither of these specialties were named as groups of non-users in the Phase 1 interviews, though interventional radiology in particular was named as a basement location within the hospital where "nothing works ever" (Interview 6) in regards to PerfectServe to due to issues with wireless connectivity.

I-PASS.

I-PASS use also varied considerably by discipline (Table 14). The process by which I-PASS was introduced meant that specialties with voluntary early adopters among chief residents were the first to try I-PASS, which could explain some of these differences. Differences in early adoption behaviors could likewise be explained by differences in disciplinary cultures, work, and workflows. Certain respondents in Phase 1 mentioned not using I-PASS due to the fact that handoffs were not part of their regular

Table 13. PerfectServe use by program.

	Do you currently use PerfectServe?		
Program	Yes	No, but I have in the past	No, never
Anesthesiology	3 (100%)	0	0
Family Medicine	4 (100%)	0	0
General Surgery	5 (100%)	0	0
Internal Medicine	6 (100%)	0	0
Oral and Maxillofacial Surgery	1 (100%)	0	0
Pathology	0	0	3 (100%)
Pulmonary Disease and Critical Care Medicine	1 (100%)	0	0
Radiology	0	1 (50%)	1 (50%)
Other	2 (100%)	0	0

n =27, p < .001 by Fisher's Exact Test

Table 14. I-PASS use by program.

	Do you currently use the I-PASS handoff procedure?			
Program	Yes	No, but I have in the past	No, never	Not sure
Anesthesiology	0	1 (100%)	0	0
Family Medicine	4 (100%)	0	0	0
General Surgery	1 (33.3%)	2 (66.7%)	0	0
Internal Medicine	0	2 (50%)	2 (50%)	0
Oral and Maxillofacial Surgery	1 (100%)	0	0	0
Pathology	0	0	0	1 (100%)
Pulmonary Disease and Critical Care Medicine	0	0	0	1 (100%)
Radiology	0	1 (100%)	0	0

n =16, p < .001 by Fisher's Exact Test

work procedures or, as discussed earlier, due to the existence of locally developed handoff procedures that better met their needs. A series of Kruskal-Wallis tests did not reveal significant differences in assessments of either innovation by program, a possible indication that while those in different programs may work in different social and physical environments, and have different communication needs and norms that impact adoption, they do not experience the innovations in significantly different ways once they become part of the work environment.

Personal Innovativeness: Innovativeness, Awareness, and Impact

Phase 2 participants' levels of agreement on the adapted Agarwal & Prasad (1998) Personal Innovativeness in Information Technology Scale (PIIT) items were somewhat high on the first and fourth items, and low in the case of the third item, which is meant to be reverse coded (Table 15). Levels of agreement with the statement *Among my peers, I am usually the first to try out new information technologies and practices*, were lower than on other non-reverse coded items, perhaps an indication that in this environment, respondents' peers are also highly innovative individuals, and perhaps equally or more likely to experiment with new innovations. Chronbach's alpha for the full scale was .78, an acceptable level of reliability. When the reverse coded final item was eliminated, alpha increased to .87. A composite innovativeness variable was created from the remaining three items. Personal innovativeness was not correlated with adoption of either innovation, however Spearman rank-order correlations revealed that there was a significant positive relationship between innovativeness and multiple

Table 15. Thinking about your technology use at work and in everyday life, please rate your level of agreement with the following.

	M (SD)	Strongly agree & agree	Neither agree nor disagree	Strongly disagree and disagree
I like to experiment with new technologies and ways of sharing information.	3.78 (0.96)	80.8%	14.6%	14.6%
If I heard about a new information technology, I would look for ways to experiment with it.	3.9 (0.89)	78.1%	14.6%	7.3%
Among my peers, I am usually the first to try out new information technologies and practices.	3.27 (1.25)	48.8%	22%	29.3%
In general, I am hesitant to try out new information technologies and practices.	2.17 (0.95)	9.7%	17.1%	73.2%

M = mean. SD= standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.

aspects of innovation assessment (Tables 16 and 17). Items that are similar assessments of innovations across both tables are italicized and in bold.

Overall, these tables show a pattern of personal innovativeness being correlated with perceptions that the innovations improve or have a positive impact on patient care and that use of the innovations makes it easier for respondents to do their jobs and enhances their effectiveness. Innovativeness was also correlated with the beliefs that use of innovations makes sense for the environment and that people who use the innovation within the environment have a high profile. This suggests that highly innovative individuals may be more attuned to the impacts of the innovations on the environment and may potentially be more aware of who within the environment is using new innovations, particularly if those other users are high profile individuals. For PerfectServe, innovativeness was correlated with knowing where to get help with technical problems if needed and agreement that training was available within the organization. It may be that innovative individuals are aware of these resources because their tendency to experiment with new innovations means that they are more likely to seek out such help, or it may be that awareness that help is available if needed increases individuals' comfort when it comes to experimenting with new innovations.

The fact that innovativeness is related to differing perceptions of innovations' impact is further evidence that factors from each quadrant do overlap and that individual differences should be considered when users evaluate new practices and technologies. If innovative individuals are indeed those more likely to perceive innovations' impact on their social environment, those with high influence who are skilled at communicating

Table 16. Assessments of PerfectServe positively correlated with assessments of personal innovativeness.

	r_s	n
PerfectServe has a positive impact on the quality of care I provide.	.59**	27
PerfectServe has a positive impact on patient outcomes.	.59**	27
People at [this organization]who use PerfectServe have a high profile.	.58**	31
If I have a technical problem with PerfectServe, I know where to get help.	.47**	30
PerfectServe improves the quality of communication at [this organization].	.46**	34
PerfectServe improves the quality of communication within [this organization].	.45*	30
At [this organization], I know many people are using PerfectServe.	.43*	30
PerfectServe is compatible with all aspects of the work of [this organization].	.43*	30
Training on how to use PerfectServe is available at [this organization].	.42*	30
It is easy to get PerfectServe to do what I want it to do.	.39*	35
PerfectServe enables me to communicate and share information more quickly.	.39*	34
PerfectServe makes it easier to do my job.	.39*	34
PerfectServe enhances my effectiveness.	.39*	34
PerfectServe makes sense for the environment in which I work.	.36*	35

**p < .05, **p < .01. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree. Items that are similar those in Table 17 are italicized and in bold*

Table 17. Assessments of I-PASS positively correlated with assessments of personal innovativeness.

	r_s	n
I-PASS improves the quality of communication during handoffs within [this organization].	.75**	13
I-PASS has a positive impact on the quality of communication during handoffs at [this organization].	.72**	13
I-PASS has improved patient safety.	.67*	13
I-PASS is compatible with my work and communication needs.	.65*	14
I-PASS makes sense for the environment in which I work.	.65*	14
I-PASS improves the quality of communication during handoffs.	.62*	14
I-PASS fits well with the way I like to communicate.	.62*	14
I-PASS fits well with the way people at [this organization] like to work and communicate.	.6*	13
I-PASS has a positive impact on the quality of care I provide.	.59*	13
It is easy to see the impact of I-PASS on the work of [this organization].	.58*	13
People at [this organization]who use I-PASS have a high profile.	.57*	13
I-PASS enhances my effectiveness.	.55*	14
I-PASS makes it easier to do my job.	.54*	14
I-PASS is not used very often in my organization.	-.55*	13

**p < .05, **p < .01. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree. Items that are similar those in Table 16 are italicized and in bold*

with others may serve as opinion leaders capable of convincing others of innovations' value, as noted in Rogers' (2003) model. In this study innovativeness was positively correlated with perceptions that the innovations improved or had a positive impact on communication and the environment. If innovations were of low value, it would be expected that innovativeness would be negatively correlated with these perceptions (Greve, 2011). In this study, no significant negative correlations between innovativeness and assessments of the innovations were observed.

Personal Preferences: "Against My Will, But Yes"

Throughout the Phase 1 interviews, respondents referred to their personal preferences for communications, as well as the preferences of others. Sometimes these preferences varied by situation, as in the case of those who preferred to be called or paged when dealing with time-sensitive or difficult patient issues. Others noted they were using an innovation despite their own personal preferences, such as the respondent who stated that they were using PerfectServe, "Against my will, but yes" (Interview 1). As will be discussed further in later sections, and in particular the section on voluntariness of use, allowing individuals the ability to communicate according to their personal preferences can create tradeoffs in a lack of standardization of communications, which can in turn lead to frustration.

Prior Experience: "They Actually Taught Us About…Why Are We Doing This"

Prior experience with the same innovation in other environmental contexts was not accounted for in the Phase 2 survey, but two of the respondents in Phase 1 did

have prior experience with one of the innovations at another organization. One had used PerfectServe as a hospitalist in another hospital. The other had previously encountered I-PASS as a medical student. In both cases, the respondent felt their prior experience had been more positive. Said the individual who had previously used PerfectServe, "PerfectServe here is more complicated in, than it should be…I liked PerfectServe where I was before. It was great" (Interview 3). Specific things this interviewee thought the other organization did well that the current organization did not included requiring physicians to use PerfectServe, limiting customization of call management algorithms, offering better technical support, having formal policies about how often individuals should be checking PerfectServe messages, reimbursing individuals for use of their personal cell phones, and providing nurses phones that could be used within the hospital to allow them to be more easily reached via PerfectServe.

For the individual who had previously used I-PASS, the way it was introduced made a difference in their experience with the innovation:

> [A]s a med student, when they taught us I-PASS, they, they actually taught us about, um, you know, why are we doing this. And we had a little instructive module that was kind of a waste of time in some ways, but did give really good information, even though it might have been equally useful information printed or emailed to us. I guess they just wanted to make sure that we actually read it. Um, which is hard to do with med students who are busy, um, if you don't do something that requires them, so I get it. But, like that was all explained to us and why this done and how it affects patient safety, and it was sort of tied into our

> evidence-based medicine and patient safety modules that we just had to do as students. We had to learn a few of these different tools and then we actually saw services that used them, which was nice. Um, when we had to do it here, they just sort of said, 'We're switching, you know, it is a patient safety initiative and you're just going to do it' (Interview 6).

For this interviewee, the instructive module that was "kind of a waste of time" also changed their experience of I-PASS by contextualizing it in a way that explained the reasons for the process, used empirical evidence, and tied it to its impact on patient safety, a core value, context they felt they were not given in their current position. Later in the interview, this interviewee contrasted their experience with that of colleague who, lacking the above context, was anxious about being required to use I-PASS. "So, it might have been actually better if someone had been like, 'Hey, this has been studied for patient safety. It helps people not miss important details that could cause adverse events for patients, and this is the outline and how it's done and how to structure your things.'" (Interview 6).

Social and Environmental Factors

Social and environmental factors are those related to the larger social and environmental context in which adoption decisions take place. In a research-intensive environment, these factors can be internal to the local environment or external factors that may not be under a group or organization's direct control, but nonetheless shape communication and innovation adoption decisions within it.

Internal Factors: "[It's] Not Necessarily Related to PerfectServe, But More Related to Our Culture at the Hospital"

As interactive innovations have the potential to not only shape, but be shaped by, the larger social context in which their adoption takes place, internal social and environmental factors can be particularly important to adoption and often to the redesign of the innovation itself.

Use of innovations by others.

As noted in the literature review, the value of interactive innovations for a particular user depends on who else within a social environment is using the innovation to communicate, and the behaviors of later adopters are influenced by the behaviors of earlier adopters (Katz & Shapiro, 1985; Markus, 1987). In the discussion of individual factors, it was noted that adoption of innovations was split along disciplinary or program lines.

PerfectServe.

In the Phase 2 survey, respondents were also asked a series of questions about who else within the social environment was using each innovation. In general, respondents had high levels of agreement that many people within the organization were using PerfectServe (Table 18). While Markus (1987) points to the importance of high-resource, high-interest individuals using the innovation, most respondents in Phase 2 neither agreed nor disagreed that users of PerfectServe had a high profile.

Table 18. Assessments of internal and external use of PerfectServe.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
Many people at [this organization] use PerfectServe.	Y (29)	4.55	0.63	93.1%	6.9%	0	4.7*
	N (2)	4	0	100%	0	0	
People at [this organization] who use PerfectServe have a high profile.	Y (29)	3.48	0.95	34.5%	62.1%	3.4%	0.71
	N (2)	3	0	0	100%	0	
At [this organization], I know many people are using PerfectServe.	Y (28)	4.61	0.57	96.4%	3.6%	0	5.67*
	N (2)	4	0	100%	0	0	
PerfectServe is not used very often at [this organization].	Y (28)	1.61	0.96	10.7%	0	89.3%	-0.57
	N (2)	2	0	0	0	100%	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

I-PASS.

For I-PASS, assessments of overall use within the organization were lower, and did not significantly vary between adopters and non-adopters (Table 19). This is perhaps unsurprising, given that I-PASS was at an earlier stage of diffusion at the time of data collection.

Table 19. Assessments of internal use of I-PASS.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
Many people at [this organization] use I-PASS.	Y (7)	3.29	0.76	42.9%	42.9%	14.3%	1.69
	N (6)	2.67	0.52	0	66.7%	33.3%	
People at [this organization] who use I-PASS have a high profile.	Y (7)	3.57	0.79	42.9%	57.1%	0	2.06
	N (6)	2.83	0.41	0	83.3%	16.7%	
At [this organization], I know many people are using I-PASS.	Y (7)	2.86	1.07	28.6%	42.9%	28.6%	-0.29
	N (6)	3	0.63	16.7%	66.7%	16.7%	
I-PASS is not used very often at [this organization].	Y (7)	2.29	0.76	0	42.9%	57.2%	-2.1
	N (6)	3.17	0.75	33.3%	50%	16.7%	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

While past diffusion research has pointed to the importance of achieving a critical mass of users in order to sustain diffusion, it is possible for this critical mass to be

achieved at the level of a subgroup; adoption need not be organization-wide. Indeed, in the case of an innovation such as I-PASS, it will not be, as not all groups within the organization have handoffs as part of their regular workflow.

Internal policies.

Both phases of the research revealed that confusion exists around the internal policies regarding use of the innovations.

PerfectServe.

In Phase 2, respondents were asked *Does [this organization] have official policies regarding the sharing of information via PerfectServe?* Over a third of adopters indicated they were not sure if such policies existed (Table 20).

Table 20. Awareness of internal policies regarding PerfectServe.

	Adopted (n)	Yes	Not Sure
Does [this organization] have official policies regarding the sharing of information via PerfectServe?	Yes (26)	65.4%	34.6%
	No (1)	100%	0

Those users who were aware of the existence of internal policies for information sharing via PerfectServe had high levels of agreement that PerfectServe is compatible with the organization's policies on information security and information privacy and confidentiality. Around two-thirds agreed that they understood the guidelines for using PerfectServe and the consequences for violating organizational policies while using PerfectServe (Table 21).

Table 21. Compatibility of PerfectServe with internal policies.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
PerfectServe is compatible with [this organization]'s policies on information security.	Y (15)	4.67	0.62	93.3%	6.7%	0	5.75***
	N (1)	1	-	0	0	100%	
PerfectServe is compatible with [this organization]'s polices on information privacy and confidentiality.	Y (15)	4.33	1.18	80%	13.3%	6.7%	2.74*
	N (1)	1	-	0	0	100%	
I feel confident I understand [this organization]'s guidelines for using PerfectServe.	Y (15)	3.73	1.44	66.7%	13.3%	20%	-0.18
	N (1)	4	-	100%	0	0	
I feel confident I understand the consequences of violating my organization's policies when using PerfectServe .	Y (15)	3.8	1.21	66.6%	20%	13.4%	-0.96
	N (1)	5	-	100%	0	0	

**p < .05, **p< .01, ***p<.0001. M = mean. SD= standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

I-PASS.

A similar question was asked about official policies for the sharing of information via I-PASS. All but three individuals—one adopter and two non-adopters—who answered this question indicated they were not sure if such policies existed (Table 22).

When internal policies governing either innovation were noted in Phase 1 interviews, it was usually in the context of voluntariness of use, to be discussed in further depth in the next section. For example, the individual who had previously used PerfectServe contrasted the organization's policies regarding PerfectServe with those that had existed at their previous institution, wishing for policy about how often users should check PerfectServe messages and policy mandating its use, as "some people are forced to use PerfectServe, and others have been given the option of how they want to use PerfectServe. So, it's kind of been a mish-mosh of we'll, we'll cater to this person, but not cater to this person, instead of, where the last place I used it, it was required" (Interview 3).

Table 22. Awareness of Internal policies regarding I-PASS.

	Adopted (n)	Yes	Not Sure
Does [this organization]have official policies regarding the sharing of information via I-PASS?	Yes (7)	14.3%	85.7%
	No (6)	33.3%	66.7%

Social norms.

Instead of formal policies universally adhered to by all users, social norms regarding appropriate communications tended to govern use of the innovations. This, combined with the fact that multiple avenues for communication exist within the environment, created areas of conflict when norms and accepted methods of communicating varied between users and groups, as was noted in the Phase 1 interviews and text responses to the Phase 2 survey. The differences in communication expectations between physicians in training and nurses were mentioned more than once. Two interviewees stated that nurses were being encouraged to use PerfectServe as a first choice for communications, even in situations where the respondents believed other methods to be more appropriate. According to one respondent, this was both a culture issue and one of expertise. While physicians preferred to be paged for acute and emergent patient issues, "[N]urses don't always know the acuity of issues. Um, like they'll PerfectServe us that a patient has chest pain. Um, that's not something that's like, should be sent in a text message, that's probably something that needs to be paged immediately, um, because it's a more acute need" (Interview 4). In some cases, this interviewee felt, nurses were using inappropriate channels for communication, not because they were unaware of how physicians wanted to be contacted, but because choosing between communication platforms required them to make a professional judgment they may not have the expertise to make, noting, "I recognize what is an acute issue, but someone else maybe does not, um, so I think those are kind of, that's a

harder dichotomy to teach, mainly, not necessarily related to PerfectServe, but more related to our culture at the hospital."

The lack of established norms for what information and how much information to send via text also came out in interviews and in free text responses in the survey. According to one survey respondent, "The ease of communication allows nursing to send the most mundane information that causes frequent, unnecessary interruptions in my work flow." Not only the frequency of messages, but also the amount of information contained in messages was experienced as a problem: "what will happen is that there's just a stream of unobstructed thought on these messages through PerfectServe from the nurses or from the respiratory therapist or from whoever is trying to contact us instead of, it could have just been, you know, a thirty second conversation" (Interview 4). The emphasis on text messaging features during initial vendor-provided training, discussed in Chapter 3, may have contributed to a tendency for nurses and other groups to select this method of communication as a first or primary choice.

As previously discussed in the section on innovation features, one interviewee found it difficult to determine an appropriate style and level of formality for communications on a work-based text messaging platform, especially one that retained messages, stating, "honestly my biggest thing that's uncomfortable about PerfectServe is it, it would be very easy to use it like a, just a general texting platform, like you were texting your friends sort of thing, but it, you always have to keep in mind that it's a professional platform at work, and this thing where they, they supposedly store every conversation on there for seventeen years and it's a complete legal document"

(Interview 5). One anonymous survey respondent was concerned about perceptions created by texting in front of patients, who may not be aware of what is being communicated and why but can only observe the behavior of a physician using a personal cell phone: "Basically we are texting about patients and required to use our personal cellular phones in front of patients who think we are texting."

In the case of PerfectServe, the differences in communication norms may be exacerbated by the fact that groups vary in how they interact with the innovation. While respondents primarily described using the phone application, they noted nurses interacted with PerfectServe primarily via a desktop interface, which created differences in how often individuals interacted with the system, as well as what information they were able to access easily. "Nurses, I know they have access on our desktop, that they can send. They can see who, who are on call, um, and many times we have to ask them, 'Hey, who's on call, because I, I can't see from here?'" (Interview 2).

Normative rightness, or the appropriateness of a speech act given existing social norms, is one of Habermas' (2001) validity claims. In this environment, evidence suggests that social norms have yet to be established around text messages in particular, and the norms that are emerging around PerfectServe are different for different groups. In the case of I-PASS, there was some evidence that the process was seen to violate established norms in that it was believed to require participants to give more information than was necessary during handoffs, at least for certain patients, and would unnecessarily prolong handoffs. Said one respondent, "To me, what makes a good handoff is very simple: I need to know, uh, what is wrong with the patient. I don't

need to know *everything* that's wrong with the patient. I need to know the most important things that are wrong with the patient. I need to know the plan for those issues in case I get called, in case nursing calls me, so that I can adequately care for a patient with quick things. I don't expect to be able to go talk to family and give an in-depth, you know, thesis about everything that's wrong with them from the checkout. That's inappropriate and that would take too long" (Interview 5).

Technical support and training.

In the Phase 2 survey, users were asked about the availability of support and training for both innovations.

PerfectServe.

Just over sixty percent of adopters agreed that training on how to use PerfectServe was available at the organization, while less than half agreed they knew who to ask a question about PerfectServe or where to get help with for a technical problem (Table 23).

Difficulty knowing where to get help within the organization for issues related to PerfectServe was also noted in interviews. "[T]he tech support here has always been a 1-800 number or whatever number is on PerfectServe. There's not any way I can call directly or ask directly about PerfectServe So, uh, luckily one of [the] attendings works highly closely with them, so if there's a concern, I just go to him and say, 'Well, I'm having an issue'" (Interview 3). If this attending was unavailable, the respondent would find a workaround or call the 800 number. Said another respondent, "on the whole, I've

Table 23. Assessments of availability of support for PerfectServe.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
Training on how to use PerfectServe is available at [this organization].	Y (28)	3.71	0.9	60.8%	35.7%	3.6%	1.06
	N (2)	3	1.41	50%	0	50%	
If I have question about PerfectServe, I know who to ask.	Y (28)	3.25	1.18	46.4%	25%	28.5%	0.29
	N (2)	3	1.41	50%	0	50%	
If I have a technical problem with PerfectServe, I know where to get help.	Y (28)	3.18	1.31	46.5%	17.9%	35.7%	0.19
	N (2)	3	1.41	50%	0	50%	

**p < .05, **p < .01, ***p < .001. M = mean. SD= standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

had to troubleshoot my own. And there's like a PerfectServe IT line or something that I had to call once when I got locked out somehow and I couldn't get in to PerfectServe. Um, and they were able to fix that over the phone. But I think I might have actually Googled to find that number…nobody knew who to call" (Interview 6).

The PerfectServe Council is a group of providers from various specialties who meet to discuss problems with PerfectServe and ways to improve it. The council functions as a way to give feedback directly to administration and the creators of PerfectServe about what is working and not working with the innovation. One of the interviewees was on the Council, and also saw this role as one of disseminating information about PerfectServe to colleagues: "I'll tell my colleagues here how PerfectServe and if the medical assistants need to know anything about it, I'll let them know what we've done. So, I kind of disseminate information for our group" (Interview 3). This interviewee was the only person in the study to bring up the Council by name. Others did not list it as a resource for support or feedback.

I-PASS.

For I-PASS, a surprising finding was that those who had adopted the innovation had significantly ($p < .05$) lower levels of agreement that if they had a question about I-PASS, they knew who to ask than those who had not (Table 24). They also, on average, had lower levels of agreement that training on how to use I-PASS was available, though the difference was not significant in this case. The reasons behind these differences, including if there are differences in introduction processes or in the resources and expertise available to various groups, is unclear.

Table 24. Assessments of availability of support for I-PASS.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
Training on how to use I-PASS is available at [this organization].	Y (7)	3	1.16	42.9%	28.6%	28.6%	-1.51
	N (6)	3.83	0.75	66.7%	33.3%	0	
If I have question about I-PASS, I know who to ask.	Y (7)	2.43	0.98	14.3%	28.6%	57.2%	-2.38*
	N (6)	3.5	0.55	50%	50%	0	

**p < .05, ** p < .01, ***p < .001. M = mean. SD= standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Wireless connectivity, technological infrastructure, and the built environment.

The built environment can impact communications within an organization in a number of ways, by limiting or enabling face-to-face interactions, or in the case of wireless communications, by limiting or enabling wireless connectivity. Four of the seven respondents in Phase 1 spoke of areas within the medical center that lacked wireless access, which contributed to missing or delayed messages and negative perceptions of the reliability of the innovation, particularly in emergency situations. While respondents varied in how much they were personally impacted by connectivity issues, the nature of their work means that delayed messages can have serious consequences. In the words of one respondent, "in our service, we're dealing with life and death and intensive care…so, you know, people need to reach us immediately, and that's where PerfectServe may be a problem" (Interview 3).

External Factors: "[I]t's HIPAA-Compliant for Us to Use It"

Social and environmental factors external to the local environment, including external laws and policies and use of innovations by peers at other organizations, can also impact adoption of innovations in health care environments.

External innovation use.

In Phase 2, respondents were asked their levels of agreement with statements about their awareness of other organizations and individuals within their field who were using each innovation (Tables 25 and 26). Few respondents agreed with any of these statements.

Table 25. Assessments of external use of PerfectServe.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
I am aware of other high profile organizations that use PerfectServe for communication.	Y (29)	2.28	1.1	10.3%	34.5%	55.1%	0.34
	N (2)	2	1.41	50%	50%	0	
Many others in my field working at other organizations use PerfectServe.	Y (29)	2.62	1.08	13.8%	44.8%	41.3%	0.78
	N (2)	2	1.41	50%	50%	0	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Table 26. Assessments of external use of I-PASS.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
I am aware of other high profile organizations that use I-PASS for communication.	Y (7)	2.71	0.76	0	85.7%	14.3%	0.11
	N (6)	2.67	0.82	0	83.3%	16.7%	
Many others in my field working at other organizations use I-PASS.	Y (7)	3.29	0.76	14.3%	85.7%	0	1.25
	N (6)	2.67	1.03	16.7%	50%	33.4%	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Awareness of other organizations' use of PerfectServe or I-PASS did not come up in the Phase 1 interviews, either, save for those who had used one of the innovations in the past. As neither innovation is typically used for external communication, this may not be a factor of importance in adoption of either innovation.

External laws and regulations.

A number of external laws and regulations govern medical communication, and some were mentioned as factors that impacted adoption and use of the innovations in this study. HIPAA regulations were mentioned specifically in two interviews when participants discussed PerfectServe's security benefits. "[I]t's HIPAA-compliant for us to use it, which is one of our big concerns" (Interview 6). As noted before, participants' reactions to PerfectServe's ability to retain messages for legal purposes varied. The fact that physicians were not allowed to give orders via PerfectServe was mentioned by three participants in Phase 1, though none noted a specific source or reason for this prohibition. When asked, one stated, "I have no idea...It doesn't make any sense" (Interview 5).

Residents' and fellows' home lives.

Residents' and fellows' home and family lives and the potential for PerfectServe in particular to disrupt this context was also mentioned in Phase 1 interviews. PerfectServe users experienced disruption of home and personal lives, particularly in cases when misdirected messages were sent via PerfectServe at inappropriate times or when multiple message reminders functioned as "the alarm clock from hell" (Interview 1) when participants or their family members were trying to sleep. The fact that

PerfectServe was required to be installed on personal smartphones also contributed to a sense of the boundaries between the professional and personal being blurred, particularly in situations when this led to a breach of personal privacy. This will be discussed in more detail later in this chapter.

Vendors and designers.

Vendors and designers, those external entities who create innovations and who are in some cases responsible for introducing them to an environment, can impact the process of adoption and diffusion, and might be directly responsible for helping tailor an interactive innovation to its social environment. In this study, vendors and designers did not play a large role in responses. Respondents hypothesized at times about designer intentions, in some cases framing these as the intentions of an innovation itself, for example, "[PerfectServe] means well. The execution seems to fall short" (Interview 1).

Use-Related Factors

Use-related factors are those are that relate to the specific uses made of the innovation as well as the way these uses impact and are impacted by the contexts of use.

Adaptability of Innovations to Context: "Probably Most Things Could Be Adapted"

PerfectServe.

The survey asked for respondents' levels of agreement with statements that they were able to make changes and adapt PerfectServe in order to better fit their work

practices, meet their own communication needs, and meet the communication needs of the people they worked with. Under a third of current users agreed that *It is easy to adapt PerfectServe to meet my needs when I am performing a specific task*; less than a quarter of current users agreed with any other statement regarding ability to adapt and make changes to PerfectServe (Table 27). By contrast, at least one respondent in Phase 1 felt that PerfectServe users were given too much choice, not only in whether or not to adopt the technology, but also in being able to modify communication algorithms, "so PerfectServe, by not having one unified algorithm, has created confusion for people" (Interview 3).

I-PASS.

Mean levels of agreement with statements about being able to adapt I-PASS were near the midpoint (Table 28). Over half of current I-PASS users agreed that they were able to make changes to better match the communication practices of the people they worked with, though less than half agreed they were able to make changes to better fit their own work practices and communication needs. This makes sense, as I-PASS is a procedure meant to standardize handoffs, and changes would need to be made at a group level to keep the process standardized. Fewer non-adopters agreed with these statements, though differences were not significant. Regardless of whether or not they felt able to do so, over 70% of adopters and 50% of non-adopters agreed that I-PASS was easy to adapt to meet their needs.

Some of those in the Phase 1 interviews who did not use I-PASS had rejected the innovation because of the existence of locally-developed procedures that had

Table 27. Assessments of adaptability of PerfectServe.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
I am able to make changes and adapt PerfectServe to better fit my work practices.	Y (31)	2.23	1.31	22.6%	9.7%	67.7%	-1.35
	N (2)	3.5	0.71	50%	50%	0	
I am able to make changes and adapt PerfectServe to better meet my own communication needs.	Y (31)	2.19	1.25	19.4%	9.7%	71%	-1.45
	N (2)	3.5	0.71	50%	50%	0	
I am able to make changes and adapt PerfectServe to better match the communication practices of the people I work with.	Y (31)	2.26	1.24	19.4%	12.9%	67.8%	-1.39
	N (2)	3.5	0.71	50%	50%	0	
It is easy to adapt PerfectServe to meet my needs when I am performing a specific task.	Y (28)	3.04	1.29	32.2%	35.7%	32.2%	0.03
	N (1)	3	-	0	100%	0	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Table 28. Assessments of adaptability of I-PASS.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
I am able to make changes and adapt I-PASS to better fit my work practices.	Y (7)	3.14	1.07	42.9%	42.9%	14.3%	-0.05
	N (6)	3.17	0.41	16.7%	83.3%	0	
I am able to make changes and adapt I-PASS to better meet my own communication needs.	Y (7)	3.14	1.07	42.9%	42.9%	14.3%	-0.05
	N (6)	3.17	0.41	16.7%	83.3%	0	
I am able to make changes and adapt I-PASS to better match the communication practices of the people I work with.	Y (7)	3.29	1.12	57.1%	28.6%	14.3%	0.25
	N (6)	3.17	0.41	16.7%	83.3%	0	
It is easy to adapt I-PASS to meet my needs.	Y (7)	4	0.82	71.5%	28.6%	0	1.27
	N (6)	3.5	0.55	50%	50%	0	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

already been adapted to communication needs or were felt to be close enough to I-PASS to make adoption unnecessary. One respondent noted that there were individual differences in the quality of handoffs "['c]ause some people leave great checkout, most people leave adequate checkout, and probably some people who leave kind of poor checkout," but also stated, "I don't know that standardizing it would actually help" (Interview 5) and believed that standardization would not change the quality of handoffs in a program were people were already providing adequate information during the process.

The user who had fully adopted I-PASS noted that the procedure was adaptable, stating, "probably most things could be adapted to I-PASS. You might just need to be more creative for some of these services than others or find ways to adjust it and make it work. Some specialties more than others have really specific or detailed information that they need to get and if they can organize it into I-PASS, it might still be just fine as a tool, but I can see how maybe it would be more challenging for some" (Interview 6).

Overall Impact: "I Don't Like to Use the Word Secretarial"

At a number of points throughout the Phase 2 survey, respondents were asked questions related to the overall impact of innovations on their own work and communication practices, as well as work and communication practices throughout the organization. Some questions in these sections overlap with questions asked previously on compatibility.

PerfectServe.

Adopters' responses when asked to agree with statements about the impact of PerfectServe on their own work and communication averaged near the midpoint in nearly every case (Table 29). Over half agreed that *PerfectServe enables me to communicate and share information more quickly*. Half agreed that PerfectServe gave them greater control of their work and had a positive impact on the quality of care they provided, while slightly less than half agreed that PerfectServe made it easier to do their jobs or enhanced their effectiveness. On many items, half or more of adopters were not experiencing positive benefits as a result of introducing PerfectServe into their own workflow.

Respondents in Phase 1 noted that at times the negative impact on their own work was the result of uneven diffusion, the fact that some individuals' contact information could not be found via PerfectServe and elimination of the call schedules that had been in place prior to PerfectServe's introduction. Many found their workflows were disrupted, or that they were doing extra work in order to figure out who within the organization to contact or how to contact them when needed. Said one respondent, "I'm doing more of, I don't like to use the word, uh, secretarial, but that's where my duties have become in some situations using PerfectServe" (Interview 1).

Respondents were also asked their levels of agreement with statements relating to the overall impact of PerfectServe on the organization (Table 30). More than sixty percent of adopters agreed that *PerfectServe increases the amount of information*

Table 29. Assessments of impact of PerfectServe on own work and communication.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
PerfectServe enables me to communicate and share information more quickly.	Y (32)	3.56	1.3	62.5%	9.4%	28.2%	1.1
	N (2)	2.5	2.12	50%	0	50%	
PerfectServe makes it easier to do my job.	Y (32)	3.25	1.39	46.9%	18.8%	34.4%	0.73
	N (2)	2.5	2.12	50%	0	50%	
PerfectServe enhances my effectiveness.	Y (32)	3.31	1.33	46.9%	21.9%	31.3%	0.82
	N (2)	2.5	2.12	50%	0	50%	
PerfectServe gives me greater control over my work.	Y (32)	3.34	1.36	50%	21.9%	28.1%	0.83
	N (2)	2.5	2.12	50%	0	50%	
PerfectServe has a positive impact on the quality of care I provide.	Y (26)	3.35	1.26	50%	26.9%	23%	1.82
	N (1)	1	-	0	0	100%	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Table 30. Assessments of impact of PerfectServe on work and communication within the organization.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
PerfectServe improves the quality of communication at [this organization].	Y (32)	3.16	1.51	50%	9.4%	40.7	0.59
	N (2)	2.5	2.12	50%	0	50%	
PerfectServe is compatible with all aspects of the work of [this organization].	Y (28)	2.75	1.48	42.8%	10.7%	46.4%	0.23
	N (2)	2.5	2.12	50%	0	50%	
PerfectServe fits well with the way people at [this organization] like to work and communicate.	Y (27)	3.22	1.34	44.4%	22.2%	33.3%	0.72
	N (2)	2.5	2.12	50%	0	50%	
PerfectServe improves the quality of communication within [this organization].	Y (28)	3.21	1.5	50%	17.9%	32.1%	0.64
	N (2)	2.5	2.12	50%	0	50%	
PerfectServe increases the amount of information shared within [this organization].	Y (28)	3.61	1.29	60.7%	21.4%	17.8%	1.14
	N (2)	2.5	2.12	50%	0	50%	
PerfectServe makes it more difficult to communicate with others at [this organization].	Y (28)	2.82	1.39	35.7%	17.9%	46.4%	-1.67
	N (2)	4.5	0.71	100%	0	0	
PerfectServe has a positive impact on patient outcomes.	Y (26)	3.27	1.25	42.3%	34.6%	23%	1.78
	N (1)	1	-	0	0	100%	
It is easy to see the impact of PerfectServe on the work of [this organization].	Y (26)	3.5	1.14	53.8%	30.8%	15.4%	-1.29
	N (1)	5	-	100%	0	0	

Table 30 (continued)

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
PerfectServe has a positive impact on the quality of communication at [this organization].	Y (26)	3.15	1.38	46.1%	19.2%	34.6%	1.54
	N (1)	1	-	0	0	100%	
Use of PerfectServe has improved patient safety.	Y (26)	3	1.23	34.6%	34.6%	30.8%	1.59
	N (1)	1	-	0	0	100%	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

shared within [this organization] and over half agreed that *It is easy to see the impact of PerfectServe on the work of [this organization].* However, less than half of adopters agreed that PerfectServe had a positive impact on the quality of communication with the organization. Additionally, less than half *disagreed* that PerfectServe made it more difficult to communicate with others. As Markus (1987) notes, interactive media have the potential to restrain as well as enable communication, and that may indeed be the case for PerfectServe in this environment, at least in some situations.

Perhaps most concerning are overall assessments of PerfectServe's impacts on the care of patients. Less than half of adopters agreed that *PerfectServe has a positive impact on patient outcomes* while nearly a quarter disagreed to some extent. Just over one third agreed that *Use of PerfectServe has improved patient safety,* while slightly under a third disagreed.

I-PASS.

Survey respondents were asked similar questions about the impacts of I-PASS on their own work and communication (Table 31). Here, adopters had significantly higher levels of agreement than non-adopters for all statements, except *I-PASS enables me to communicate and share information more quickly*. The length of time I-PASS takes was mentioned as a disadvantage in interviews. The majority of adopters did agree with all of the statements, with over 85% agreeing that *I-PASS has a positive impact on the quality of care I provide*.

On questions related to the impact of I-PASS on work and communication within the organization, there were again significant differences (Table 32). Those who had

Table 31. Assessments of impact of I-PASS on own work and communication.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
I-PASS enables me to communicate and share information more quickly.	Y (8)	3.5	1.41	62.5%	12.5%	25%	0.9
	N (6)	3	0.63	16.7%	66.7%	16.7%	
I-PASS makes it easier to do my job.	Y (8)	4	0.93	62.5%	37.5%	0	2.27*
	N (6)	2.83	0.98	16.7%	66.7%	16.7%	
I-PASS enhances my effectiveness.	Y (8)	4.13	0.83	75%	25%	0	2.75*
	N (6)	3	0.63	16.7%	66.7%	16.7%	
I-PASS gives me greater control over my work.	Y (8)	3.88	0.835	62.5%	37.5%	0	2.71*
	N (6)	2.67	0.82	0	83.3%	16.7%	
I-PASS has a positive impact on the quality of care I provide.	Y (7)	4.14	0.69	85.7%	14.3%	0	3.03*
	N (6)	3.17	0.41	0	16.7%	83.3%	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Table 32. Assessments of impact of I-PASS on work and communication within the organization.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
I-PASS improves the quality of communication during handoffs.	Y (8)	4.13	0.99	87.5%	0	12.5%	2.42*
	N (6)	3	0.63	16.7%	66.7%	16.7%	
I-PASS is compatible with all aspects of the work of [this organization].	Y (7)	4.14	0.69	85.7%	14.3%	0	3.09*
	N (6)	3	0.63	16.7%	66.7%	16.7%	
I-PASS fits well with the way people at [this organization] like to work and communicate.	Y (7)	4.14	0.69	85.7%	14.3%	0	2.44*
	N (6)	3.17	0.75	33.3%	50%	16.7%	
I-PASS improves the quality of communication during handoffs within [this organization].	Y (7)	4.29	0.76	85.8%	14.3%	0	2.6*
	N (6)	3.33	0.52	33.3%	66.7%	0	
I-PASS increases the amount of information shared during handoffs within [this organization].	Y (7)	3.57	0.98	57.2%	28.6%	14.3%	1.62
	N (6)	2.67	1.03	16.7%	50%	33.4%	
I-PASS makes it more difficult to communicate with others at [this organization].	Y (7)	2.43	1.27	14.3%	14.3%	71.4%	-0.43
	N (6)	2.67	0.52	0	66.7%	33.3%	
I-PASS has a positive impact on patient outcomes.	Y (7)	3.86	0.9	57.2%	42.9%	0	1.26
	N (6)	3.33	0.52	33.3%	66.7%	0	
It is easy to see the impact of I-PASS on the work of [this organization].	Y (7)	4	0.82	71.5%	28.6%	0	2.26*
	N (6)	3.17	0.41	16.7%	83.3%	0	

Table 32 (continued)

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
I-PASS has a positive impact on the quality of communication during handoffs at [this organization].	Y (7)	4.29	0.76	85.7%	14.3%	0	2.11
	N (6)	3.5	0.55	50%	50%	0	
I-PASS has improved patient safety.	Y (7)	4	0.82	71.5%	28.6%	0	1.27
	N (6)	3.5	0.55	50%	50%	0	

**p < .05., ** p < .01, ***p < .001. M = mean. SD = standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

adopted I-PASS had significantly higher levels of agreement that *It is easy to see the impact of I-PASS on the work of [this organization]* and that I-PASS improves the quality of communication during handoffs both in general and within the organization, is compatible with all aspects of the work of the organization, and fits well with the way people at the organization like to work and communicate.

Over seventy percent of adopters and half of non-adopters agreed that I-PASS has improved patient safety. Over half of adopters agreed that I-PASS has a positive impact on patient outcomes, though only a third of non-adopters agreed; the rest neither agreed or disagreed.

Specific Use Contexts and the Case of Sterile Procedures: "You Have to Let Somebody Unlock Your Phone"

In an environment in which highly specialized work is being done, an interactive innovation may be more or less appropriate or may have different impacts on communication depending on the specific uses and contexts of use. Evidence of this was presented throughout the Phase 1 interviews, in which some respondents preferred other options for communicating, such as phone or pager, over PerfectServe, depending on the nature and/or urgency of the communication. With I-PASS, locally developed procedures were at times seen as being more appropriate for handoffs given the specific nature of the work, and some non-adopters did not adopt specifically because, in the words of one anonymous survey respondent, "I practice in a field that does not 'hand-off' patients, so I-PASS is irrelevant."

In studying adoption of PerfectServe, it is important to consider both the context of the innovation and the context of the user. In this environment, users were require to install PerfectServe on their personal cell phones. Having the application installed in this context presented a number of issues for users. By using their own devices, users incurred a number of personal costs that were not reimbursed by the organization, including wear and tear on the phone, battery drain, and the costs of using a personal data plan when not connected to the organization's WiFi. While to some users this was "not a big deal" (Interview 2), others saw ethical and legal issues with the fact that, according to another interviewee, "I'm paying to…work for this hospital, because I'm using my personal cell phone" (Interview 3). Another user noted changes in the way they were interacting with their phone, stating, "I guess I'm more willing to check it, even if I'm talking to a patient, since I just assumed it was something personal before, and now I have no idea. It could be somebody from the hospital. It could be an emergency," adding, "I guess that's more of just a personal issue with it, where it's like my personal and professional lives are crossing and entangling more than maybe I realized or intended" (Interview 6).

For PerfectServe users who performed sterile procedures, this entangling of the personal and professional on a single device created serious privacy concerns when they were in a context like the operating room. "So, if for instance if we're in the operating room, we're scrubbed in and we can't touch our stuff because that would contaminate things, and so we have to give our PIN to one of the nurses or a tech that's in the room in order to unlock our phone and read whatever the message is. And so

we're forfeiting our, our PIN" (Interview 7). "[I]t's a big issue, it's a privacy issue, 'cause you have to let somebody unlock your phone, get on your phone, tell 'em your password, and let them check your PerfectServe message. And that's, to me that's grossly inappropriate. And that's a real issue. That's like, that' s a, that's a very specific issue, but that's a very real issue for [surgery residents]" (Interview 5). In this case, a specific issue that occurred due to specific overlapping contexts of use created considerable costs in terms of personal privacy for those affected by it, as they were at times required to relinquish control of their personal device and give access to the data on it to someone else within the work environment. The possibility of incurring non-reimbursed monetary costs if a phone was dropped and broken by a coworker in course of checking a PerfectServe message was also mentioned by two of the interviewees.

Voluntariness of Use: "I Don't Have to Like It"

One of the limitations of the current study is the extent to which innovation adoption was perceived as non-voluntary by innovation users. While adoption of neither innovation was mandated throughout the entire organization, multiple users in the study described their role in their own adoption decisions as follows:

- "I don't have to like it, but, you know, I also don't like doing night shifts, but I have to" (Interview 1).
- "[T]hey told us we had to download it on our phone and that that would be the paging system, and that was that" (Interview 4).
- I was told, 'This is PerfectServe. We're gonna use it. Have fun.'" (Interview 5).

- I was told to install [PerfectServe]. I never heard of it before…They were like, 'Everyone has to have it. Make sure you have it by this date.'" (Interview 6).
- I realized when they said, 'Hey, we're doing I-PASS' how similar it was to what we were doing [with the existing handoff procedure] and I said, 'That won't be too bad.'" (Interview 6).
- "I started using [PerfectServe] from day one. Yeah. I like it, but we're stuck with it" (Interview 7).

The Phase 2 survey asked respondents two questions about the voluntariness of their use of PerfectServe. Over 85% of adopters disagreed with the statement *My administration does not require me to use PerfectServe,* though only slightly over 50% disagreed that *Although it might be helpful, PerfectServe is not compulsory in my job*, perhaps because use was not mandated for everyone within the organization (Table 33).

Because PerfectServe is a multi-faceted innovation with multiple functions, questions were also asked to determine to what extent users had fully adopted PerfectServe. Less than 50% of users agreed with the statement *I use all the available features of PerfectServe*, and over two-thirds agreed *There are some features of PerfectServe with which I am unfamiliar* (Table 34). Evidence of unfamiliarity with all features of PerfectServe was also present in Phase 1 interviews. Users noted features and abilities that they had discovered over time or did not know about at the time of the interview but could not be certain didn't exist. Said one user, discussing the need for repetition of the same steps multiple times while using PerfectServe, "there might be a

Table 33. Assessments of voluntariness of use for PerfectServe.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
My administration does not require me to use PerfectServe.	Y (28)	1.64	1.1	10.7%	3.6%	85.7%	-3.01**
	N (1)	5	-	100%	0	0	
Although it might be helpful, PerfectServe is not compulsory in my job.	Y (28)	2.39	1.32	21.4%	25%	53.6%	1.04
	N (1)	1	-	0	0	100%	

**p < .05, **p < .01, ***p < .001. M = mean. SD= standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Table 34. Assessments of full adoption for PerfectServe.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
I use all the available features of PerfectServe.	Y (28)	3.43	1.03	46.5%	32.1%	21.4%	0.41
	N (1)	3	-	0	100%	0	
There are some features of PerfectServe with which I am unfamiliar.	Y (28)	3.68	1.28	67.9%	14.3%	17.8%	0.52
	N (1)	3	-	0	100%	0	

**p < .05, **p < .01, ***p < .001. M = mean. SD= standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

secret hidden menu or something like that, but none that I've discovered or heard of yet" (Interview 1). Said another about the ability to look people up by name, "That's actually something I didn't know how to do at first, so I had to figure out how to look people up by name, but it seems obvious in hindsight" (Interview 6).

For I-PASS, the survey suggested that at least some users viewed adoption as mandatory (Table 35). Almost sixty percent of current users disagreed that *My administration does not require me to use I-PASS,* and almost thirty percent disagreed that *Although it might be helpful, I-PASS is not compulsory in my job.* Interestingly, just over 15% of non-users also disagreed with both statements, despite reporting not currently using I-PASS themselves.

Table 35. Assessments of voluntariness of use for I-PASS.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
My administration does not require me to use I-PASS.	Y (7)	2.71	1.38	28.6%	14.3%	57.2%	-0.71
	N (6)	3.17	0.75	33.3%	50%	16.7%	
Although it might be helpful, I-PASS is not compulsory in my job.	Y (7)	3	1.29	28.6%	42.9%	28.6%	-0.78
	N (6)	3.5	1.05	50%	33.3%	16.7%	

**p < .05, **p < .01, ***p < .001. M = mean. SD= standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

The Role of Values in Innovation Adoption

RQ3: Do individual, organizational, and professional values impact innovation adoption in research-intensive health care environments? If so, what values are in play?

Phase 1 interviews were coded for references to personal or professional values that played a role in adoption decisions or were referenced in participants' discussions of the innovations. Words and concepts included:

- Value concepts identified in Cheng and Fleischmann's (2010) meta-inventory of human values;
- Concepts related to Longino's (1990) constitutive values of science;
- Professional values in the field of health and medicine identified in the literature review.

In the case of these particular innovations, value concepts that repeatedly emerged from interviews as important to users in the context of their use of the innovations included patient health and safety and patient lives; personal privacy; security; time; and work-life balance. Other value concepts coded as particularly important more than once in interviews included convenience, a value concept related to time, and information standardization, a concept related to information quality. The value of permanence, particularly as related to the permanence of information in a fixed digital or physical medium, was dropped from the study when it could not be consistently coded.

Patient Health, Patient Safety, Patient Lives

As expected, physicians in training place a high value on patient health and safety, and related to that, on the quality of patient care they are able to provide. In

some cases, respondents note, they are quite literally "dealing with life and death" (Interview 3). When use of an innovation constrains communication rather than enabling it, the consequences can be very serious. It was the belief of one anonymous survey respondent that "PerfectServe has gotten people killed."

The Phase 2 survey results indicate that not everyone believes that use of PerfectServe has a positive impact on patient health and safety; less than half of current users of PerfectServe agreed the innovation had a positive impact on patient outcomes, and fewer agreed that it had improved patient safety. A number of survey and interview responses revealed that, at least at times, use of PerfectServe directly conflicted with these values. Some examples have been discussed earlier. Others include:

- "Some patient safety issues exist where nurses will PerfectServe a message about an unstable patient that would be more effectively communicated by a page" (survey response).
- "PerfectServe has made it difficult to page certain specialties in urgent situations, leading to harm in patient care" (survey response).
- "PerfectServe did nothing to improve the system that was in place and has been a detriment to patient care" (survey response).

The interview participant who had used PerfectServe at a previous institution believed that it wasn't PerfectServe itself, but rather its implementation that had created potential issues for patient care. Speaking of their previous experience, they noted, "Less cognitive load, but also better communication, better care for the patient, because it was more rapid communication, the way PerfectServe is intended to work, as rapid

communication, appropriate communication, uh, and direct communication. Whereas here, there's loopholes. And loopholes never are, are always at a higher risk for having a, a bad outcome" (Interview 3). As mentioned previously, the fact that communication issues might lead to serious consequences for patients made respondents less tolerant of bugs and problems with the innovations, even if these issues were eventually resolved.

Patient safety is also a value important to the design and implementation of I-PASS. Said one interview participant, "[I-PASS] is a very good system as far as making sure that people don't miss things. Which, human error, everyone, everyone's gonna be prone to it. So, it, I, I think it's a good tool for safety, and I would like to work somewhere that has kind of that culture of safety and wanting people to communicate better and miss fewer things" (Interview 6). However, for other interviewees, the level of standardization provided by I-PASS was unnecessary, at least for the safety of every patient. "I-PASS is, I guess, built to check out your most acute patients, which we do, the ICU patients which are our most acute, um, and then we check out our new patients, but really, for all the other services, I feel like it's probably not that appropriate because most of the other patients are very stable, and um, like if something were to come up urgently, I-PASS wouldn't change, like, our checkoff system" (Interview 4).

Privacy: "I've Been a Patient…and Privacy's Important"

Personal privacy and the protection of sensitive information was a concept that emerged multiple times in the interviews, not only when considering the privacy of patients and the protection of their personal information, but also when considering the

personal privacy of respondents themselves. The fact that PerfectServe's security features protected patient privacy was an important characteristic of this innovation. Said one respondent, "I've been a patient, and I've had family members in the hospital, and privacy's important. It's really frustrating to people if their personal data is being broadcast into the world" (Interview 6). However, while protection of patients' information was built into PerfectServe's design, protection of users' personal information did not appear to have been as well considered in PerfectServe's implementation within this environment. The need for residents and fellows performing sterile procedures to relinquish their personal phones and passcodes to others within the environment or risk missing crucial messages created privacy concerns around the protection of data stored on personal phones.

Security: "It's Great Because It's Secure Communication"

Security, specifically the security of electronically transmitted information, is a value concept closely related to privacy and was also mentioned multiple times in the Phase 1 interviews. The security features of PerfectServe were noted as a positive benefit of the innovation by six of the seven interviewees, with statements like "it's great because it's secure communication" (Interview 4). The security of messages sent via PerfectServe was seen as a positive aspect of the innovation, even by interviewees who were otherwise predominantly critical of it. One participant did express frustration about the extra security-related step of having to enter a passcode to sign into PerfectServe after they had already signed into their personal phone. The value of security goes hand-in-hand with the value placed on privacy, particularly when the sharing of patient

information over electronic systems is involved. The fact that PerfectServe's security made it compliant with HIPAA regulations was mentioned specifically by two interviewees. The security features of PerfectServe gave it advantages over text messaging via other apps—and in some cases, advantages over verbal communications that could be overheard by others—because it allowed respondents to share information they otherwise could not, though what specifically differentiates PerfectServe's security from other text messaging applications, such as Apple's iMessenger, may not be entirely clear: "[Apple made an] easy to use, idiot-proof system of communicating with somebody that's only behind one layer of security, and it's encrypted as far as I understand. It's just not HIPAA-compliant" (Interview 1). As noted by one interviewee, secure texting opened up possibilities for communication that had not previously existed:

> being able to, like, send an EKG or a picture of a wound or something that usually you really can't do because it's not secure enough and it doesn't protect the patient's privacy enough. Um, that's really useful. Um, a lot more useful than I even thought when they first said that we were going to start using this. Um, probably just 'cause I hadn't thought of the possibilities. There'd never been anything like it. I couldn't do any of that before (Interview 6).

Security was not a concept mentioned often in discussions of I-PASS and handoff procedures, though one participant stated, "the way we do [handoffs] now is by way of a secure email that goes out to the, uh, relevant parties" (Interview 1),

specifically noting that for email "[the] platform that this hospital's adopted, um, I understand is HIPAA-compliant, it's secure."

Statements related to security and privacy of information shared via PerfectServe and I-PASS were also included in the Phase 2 survey (Tables 36 and 37). Almost 90 percent of users agreed that information shared via PerfectServe is secure and over 85 percent agreed that PerfectServe protected the privacy and confidentiality of patient information. Mean levels of agreement with the statement *PerfectServe protects* my *privacy and the confidentiality of* my *information* were lower; over a quarter of respondents disagreed with this statement.

Table 36. Assessments of security and privacy of information shared via PerfectServe.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
Information shared via PerfectServe is secure.	Y (28)	4.46	1	89.3%	3.6%	7.2%	0.73
	N (2)	3	2.83	50%	0	50%	
PerfectServe protects patient privacy and the confidentiality of patient information.	Y (28)	4.29	1.27	85.7%	3.6%	10.7%	1.29
	N (2)	3	2.83	50%	0	50%	
PerfectServe protects my privacy and the confidentiality of my information.	Y (28)	3.7	1.54	62.9%	11.1%	25.9%	0.6
	N (2)	3	2.83	50%	0	50%	

**p < .05, **p < .01, ***p < .001. M = mean. SD= standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

Table 37. Assessments of security and privacy of information shared via I-PASS.

	Adopted (n)	M	SD	Strongly agree or agree	Neither agree nor disagree	Strongly disagree or disagree	*t*-test
Information shared via I-PASS is secure.	Y (7)	4.71	0.49	100%	0	0	2.51*
	N (6)	3.33	1.37	50%	33.3%	16.7%	
Patient information shared via I-PASS is private and confidential.	Y (7)	4.57	0.79	85.7%	14.3%	0	2.04
	N (6)	3.33	1.37	16.7%	33.3%	50%	

**p < .05. M = mean. SD= standard deviation. Results based on a 5-point Likert scale: 1 = Strongly disagree, 5= Strongly agree.*

For I-PASS, there were differences between adopters and non-adopters in assessments of privacy and security (Table 37). All current users agreed that information shared via I-PASS is secure, but mean levels of agreement were significantly lower for non-adopters. While the majority of current users also agreed that patient information shared via I-PASS is private and confidential, half of non-users disagreed. A statement about the privacy and confidentiality of respondents' own information was not included, as this was not deemed to be relevant to handoff processes.

Time: "It's Hard Because There's So Much Information...And Not a Lot of Time"

As expected, residents and fellows place a high value on their time, and this was evident in their discussion of both innovations. Rarely was either innovation mentioned as a time saver. For PerfectServe, technical issues, cumbersome menu structures, lags in receiving messages, and system crashes all contributed to lost time for users. Even when the application performed as expected, the steps it added the communication process took time from residents' and fellows' work, and the time cost of those multiple steps, even if they individually took only seconds, added up:

> There's launching the application, which a lot of times, it doesn't automatically refresh, and so the application, um, the startup time is, is prolonged, as compared to just firing up my phone and hitting call. Um, it asks you to validate, even though you've, you've tapped into your phone, or you've fingerprinted into your phone, it asks you to do that again, so there's a second fingerprint check or, um, a passcode check. So that's an extra couple seconds. And then you have to find the

> contact and there's a whole host of menus, um, that you have to navigate through to find the appropriate person via, y'know, if you're trying to call for an emergent cardiology consultation it'll ask you if it's a new in-patient or a new patient, if you want the on-call cardiology fellow, if you want to go straight to the attending, um…it, it, so it's, it does a lot to try and divert the communique to the right person, um…or, but I think it, it assumes that you don't know who the right person is at the time, so it tries to help facilitate that, getting you that information, but oftentimes, you know who that right person is. You don't want to have to go through all those hoops every time, you'd just rather be able to call that person directly. And I think nothing beats a, 'Hey, do you have a second? Can I chat with you?' kind of a communication, you know (Interview 1).

Time was often directly related to patient health and safety, and participants were concerned that lags in communication or in the receipt of messages could have very serious consequences. Respondents reported delays of 25-30 and even 45 minutes in receiving messages, though one respondent noted this wasn't necessarily a disadvantage when compared with the existing pager system, as "there are pages that come through late, or that, you know, they had the pager number off by one digit and that I haven't gotten that I was very upset when I realized that something that was more urgent had been delayed thirty, forty-five minutes, an hour, that really shouldn't have waited that long" (Interview 6).

PerfectServe's ability to alert users about unchecked messages has been discussed, but even with this backup system, there was sometimes a delay. Issues with

wireless connectivity were perceived to contribute to the problem: "I don't get great service throughout the hospital and so I don't always get my PerfectServes on, you know, as soon as they come through. Um, so I'll walk through a separate part of the hospital and I'll get twenty PerfectServes…and some of them are more acute than others" (Interview 4). There were also scenarios when other methods of communication were perceived to offer a distinct time advantage over PerfectServe: "[I] log into PerfectServe, which is annoying, um, then wait for PerfectServe to load, look at the message, then type my message back and then like confirm all this, when I could have just, like, called them on the phone and said, 'Hey, this is what you should do.'" (Interview 4). Waiting for others to reply via PerfectServe also took time; this was particularly true for conversations with nurses, "as they have to use the desktop to log back into the PerfectServe system to see my replies" (survey response).

Finally, PerfectServe users experienced spending more time trying to figure out who within the medical center to contact and how to contact them. This was the frustration of the user who felt their duties were becoming more "secretarial" in relation to PerfectServe. This same user also described performing "tech support" functions in helping others use PerfectServe, adding "I'm here to learn. I'm here…to be educated, not be, uh, working secretarial duties" (Interview 3).

Time was also mentioned as a value in relation to I-PASS. Some participants preferred locally developed procedures to the I-PASS process because of the time the latter was expected to take:

- "If we had to I-PASS every single one of our surgery patients, we would be here for four hours. Our, our handoffs are roughly thirty minutes" (Interview 4).
- "if you standardize [the handoff], it would just make it longer for some times when it wasn't necessary" (Interview 5).
- "It's hard because there's so much information, there's, there's a significant amount of information and not a lot of time" (Interview 7).

The benefits of switching to I-PASS were not believed to be worth the expected time expenditure for these participants.

Work/Life Balance: "[E]veryone Can Reach You All the Time"

Issues impacting work/life balance were mentioned with regards to using PerfectServe in five of the seven interviews. Beyond the personal privacy issues and "crossing and entangling" of personal and professional lives resulting from being required to use a personal cell phone for work, there were issues related to the disruption of residents' and fellows' home lives due to PerfectServe messages or message reminders. Respondents spoke of PerfectServe disturbing their own sleep or that of family members and of misdirected communications and being contacted at inappropriate times via PerfectServe. Whether this represented a disadvantage as compared to the pager system depended on the respondent. Said one, "on transplant we carry the pager 24/7, um, so going home, you know, may be, you know, getting a page at two in the morning is not really necessary for a patient that just needs Tylenol, it is something that can be handled with a PerfectServe, so…some of those things are a little bit easier to deal with on PerfectServe" (Interview 4). Said another, "[it] is horrifying

in one way because, you know, just everyone can reach you all the time, including at home now with PerfectServe, whereas our pagers we could turn off, PerfectServe stays around, calls us" (Interview 6). This same resident noted another potential issue with the PerfectServe application that did not exist for the pager: because their phone was now both a personal and work communication device, the risk of accidentally leaving the phone at home was higher.

Interaction Between Quadrants

RQ4: Are there other factors important to interactive innovation adoption in research-intensive health care environments that are not included in the research model?

While a new category of factors related to innovation adoption did not arise from this research, the study did point to the importance of identifying and understanding how factors from the four quadrants overlap and interact in a given environment, as challenges caused by these interactions can have unexpected effects on innovation adoption. For example, in the case of PerfectServe, use of the application on a mobile device requires wireless connectivity, an *innovation factor*. Within this organization, connectivity was an issue in certain areas of the hospital, an *environmental factor*. As a result of connectivity problems, users sometimes experienced delays in receiving messages, which led them request that others not use PerfectServe for a particular use: contacting them with time-sensitive patient issues, which represents a *use-related factor*. This created conflict not only do to the fact that nurses were seen to have different norms and training around communication practices than residents and fellows—a *social factor*—but also due to the fact that, according to one respondent,

choosing a communication medium based on these criteria requires nurses to make a judgment call, namely which patient issues are acute, that they may not have the training and expertise to make, an *individual factor*.

A similar interaction was seen in the case of sterile procedures. One factor related to PerfectServe as an *innovation* is that it is a technology dependent on other technologies. The app must be installed on a mobile device, which in this *environment*, per organizational policy, is the user's personal smartphone. This technical context of *use* creates personal privacy concerns when users are in the context of the operating room, performing sterile procedures, as they cannot touch their phones, which means they are required to hand over their passcode to someone else within the work environment or risk missing critical messages. While this issue impacts only those *individuals* who perform sterile procedures and only at specific times, the impact was great enough that it was raised in interviews as a serious concern.

The next chapter details conclusions that can be drawn from this research and presents recommendations for future research based on the model.

CHAPTER FIVE
DISCUSSION AND CONCLUSIONS

A number of factors impact the adoption of interactive innovations in research-intensive health care environments and use of these innovations will in turn impact the social systems in which they are introduced, often in unintended ways. The previous chapters presented a new model for examining the diffusion of interactive innovations in research-intensive environments and the results of an exploratory study using that model to examine the adoption of two interactive innovations by physicians in training at an academic medical center. This chapter provides an in-depth discussion of these results and provides recommendations for future research.

Diffusion of PerfectServe and I-PASS

Rogers (2003) conceptualized diffusion as a five-stage process moving from initial knowledge of an innovation to confirmation of the decision to adopt or reject it. At the time of the study, most respondents had some knowledge of PerfectServe and most had adopted and implemented it (Rogers' third and fourth stages of diffusion), whether or not those decisions were perceived to be voluntary. I-PASS was at an earlier stage of diffusion; not all respondents reported knowledge of the innovation, and among those who were aware of it, some had made the decision to reject it. As adoption was seen as non-voluntary in the case of PerfectServe in particular, Rogers' second stage of diffusion, persuasion, was not necessarily experienced by respondents as conceptualized. Not all respondents were necessarily persuaded of the innovation's

value and not all had a favorable attitude toward the innovation, instead adopting it because "They told us we had to." This had impacts on use and information sharing, as will be discussed later in this chapter. At the time data were collected, the introduction of these innovations did not yet represent a small-scale "creative destruction" of communication systems and processes within the medical center, as new technologies and processes had not yet replaced old ones. While new ways of doing things and new possibilities for communication were now available, they had not replaced, but instead now existed alongside older technologies and processes, creating additional decision points when individuals wished to communicate.

Revisiting the Pollock Model of Interactive Innovation Adoption (PMIIA)

Factors from all four quadrants of the model were found to impact adoption of interactive innovations in this research. Additionally, as expected, factors from all four quadrants overlapped with each other in this context, at times with unforeseen consequences for innovation use and information sharing.

Innovation Factors: Understanding and Overcoming the High Costs of Use

Innovations' ease of use, relative advantage, and compatibility were shown to impact innovation adoption in this environment. A further study of how users viewed these characteristics and how innovation factors interact with factors from the other three quadrants can potentially inform the assessment and dissemination of future innovations.

The fact that adopters of I-PASS had significantly higher levels of agreement with statements related to ease of use in the Phase 2 survey is unsurprising, and consistent with results from other studies of innovation diffusion. For PerfectServe, which is an innovation with multiple functions, ease of use was a less straightforward thing to define, leading one interviewee to note, "it's not that difficult to use when it works." To the extent that interviewees characterized PerfectServe itself as actor within the social system, it was described as one with good intentions, with statements like "it means well" and "it tries to help," even if users felt it fell short of its goals in actually being helpful.

In addition to specific features they found complex or frustrating, users of PerfectServe also mentioned a number of bugs and technical errors, problems with misdirected messages, and problems finding alternate contact information for non-users of PerfectServe. As noted in this study, some of these issues may not have been directly related to the innovation itself, but rather to choices made in its implementation, and to the choices made by individuals and groups when customizing the innovation and making their contact information available to others. Respondents noted that some of these issues were not unexpected, given that PerfectServe represented both a new technology and a new way of doing things, and some issues had already improved with time. However, the nature of interactive innovations makes the early costs of adopting these innovations already high. New technologies and processes must be learned. New social norms, as will be revisited later, must be established. Before the innovation is fully diffused, there is a cost of duplicate effort associated with sending a message via

both new and existing communication channels, or, as was seen the current study, a cost of effort in determining which users may be reached via which channels and deciding which methods for communicating particular messages are most appropriate. Dealing with what an interviewee described as "bugs and kinks" in the early days of standing up a technical innovation adds still more upfront cost to the user experience. Work in health care organizations is extremely time sensitive; residents and fellows place a high value on their time, which is often directly connected to their ability to provide appropriate care for their patients, and they are likely to have negative perceptions of innovations they feel add unnecessary time to communication processes. The costs of miscommunication or missed communications can also be very high, as residents and fellows are sometimes literally dealing with life and death in the work they do. When performing time-sensitive work and dealing with patient care, users understandably have little patience dealing with innovation-related problems, even if these are to a certain extent expected or viewed as inevitable.

Assessments of the innovations' trialability may be related to at least some perceptions of ease of use. On average, users disagreed that they had been given a chance to try out either innovation or to see what the innovation could do before using it. Respondents were learning and discovering new PerfectServe features and encountering problems for the first time on the job. Additionally, many did not know who to contact with PerfectServe technical issues or questions about either innovation, even though technical support was available. The nature of interactive innovations—particularly the fact that their full functionality depends on a certain level of adoption by

others—in addition to the fact that time is often at a premium for residents and fellows and adoption decisions sometimes involuntary, may make a lengthy period of user experimentations with innovations before implementing them impractical. Additionally, problems or incompatibilities may not be discovered until the innovation is fully implemented in a real-world context.

Perceptions of relative advantage also played a role in adoption and use. Some users did see a relative advantage in using PerfectServe, at least in some situations, and pointed to beneficial features such as its security, the ability to send images, and the ability to tell when a sent message had been read. By contrast, at least in some situations, some users saw relative advantages in using existing methods of communication, such as the pager system, voice phone calls, or face-to-face conversation, instead. Many had strong preferences regarding how they wished to be contacted, which the research revealed did not always match other users' practices, which may have in part been shaped by the training they received. With handoffs, some felt that existing, locally developed procedures offered a relative advantage over I-PASS or were similar enough to make switching to I-PASS unnecessary.

In Rogers' (2003) knowledge phase, a potential adopter "learns of the innovation's existence and gains some understanding of how it functions." In interviews, all of those who knew of the innovations had at least this basic understanding. However, Trudel et al. (2017) distinguish between three types of knowledge: know-what (what the innovation is and what it does), know-why (rationales for adopting the innovation), and know-how (strategies for adopting, implementing, and assimilating the innovation in an

organizational context). For these innovations, it appeared that information related to know-why and know-how had not necessarily been diffused along with the innovation, and in some cases, information related to know-what was also lacking. Some participants described their introduction to PerfectServe in terms of being given very little information beyond the fact that they were required to use it. Similar knowledge gaps existed for I-PASS. This finding is curious in light of the fact that transmission of all three types of knowledge seemed to be considered in introductory processes as described to the researcher, and in particular, covered in the change process that informed I-PASS's introduction (Kotter, 2012). This is a potential area for future research. The experiences of one interviewee who had encountered I-PASS as a medical student provide an interesting contrast to these findings. This interviewee's first introduction to I-PASS involved a process that was deemed "a waste of time in some ways," but covered not only the features of I-PASS, but the reason for its existence and evidence for how use of the process impacted patient safety. This introduction made this interviewee more accepting of I-PASS and less anxious about its use than a colleague who had not received a similar introduction.

Perceptions of compatibility—"the degree to which an innovation is perceived as being consistent with existing values, past experiences, and needs of potential adopters" (Rogers, 2003)—are often found to be correlated with adoption behaviors, and such was the case in this study. Adopters of I-PASS had significantly higher levels of agreement than non-adopters that I-PASS was compatible with their work and communication needs, communication preferences, and work styles. Compatibility may

be particularly difficult characteristic to assess prior to an innovation's introduction, especially from outside an environment, as it requires not only having information about the innovation, but also information about potential adopters, their social environments, and the specific uses to which the innovation is expected to be put, the other three quadrants of the PMIIA model.

Individual Factors: Different Users, Differing Assessments

Individuals capable of making innovation adoption decisions differ in their characteristics, past experiences, information needs, and other factors, and all of those differences can impact adoption. In this study, adoption decisions varied significantly by specialty or program. Perceptions of innovations were found to differ by gender and personal innovativeness. Findings for this quadrant suggest a number of areas for future research that again offer important insights for the introduction of future innovations.

Within this environment, an individual's program or specialty was highly correlated with adoption of both innovations, and in fact, adoption was split almost entirely along program lines. Residents and fellows in different programs do different work, have differences in physical and social work environments, and likely have different communication patterns and needs. Some may not need the innovation at all. For example, if handoffs are not part of one's workflow, the I-PASS handoff procedure will be, in the words of one respondent, "irrelevant." Any and all of these differences may play a role in adoption decisions.

Among survey respondents who answered demographic questions, there were also differences in assessments of innovations along gender lines. Female respondents had significantly lower levels of agreement than male respondents on statements related to the trialability and adaptability of PerfectServe and their awareness of its use by others in their field. They also had significantly lower levels of agreement than male respondents on statements related to the compatibility and impact of I-PASS. Why these differences exist is presently unclear, and gender was not mentioned as a factor in Phase 1 interviews. This is another area worthy of future exploration.

Overall, respondents to the survey do see themselves as personally innovative, if not necessarily the first among their peers to try out new innovations. This could be the result of comparing oneself to a group of other innovative individuals. Evidence from this study suggests that highly innovative individuals do perceive the innovations to be of value; find PerfectServe easier to use; are more attuned to the impacts of innovations on patient care, communication, and their own work; and may be more aware of who is using innovations and how to seek more information about them. This is consistent with Rogers' (2003) characterization of innovators as those motivated to seek out new information, who often function as gatekeepers in introducing innovations to a social system. Social network analysis could reveal where these innovative individuals are placed within the social systems of the medical center. If any are found to have high levels of social influence, these individuals can function as opinion leaders, capable of influencing others to adopt an innovation. With their awareness of the impact of innovations, these individuals are also potentially capable of identifying a low value

innovation relatively earlier in the diffusion process and discouraging diffusion before additional resources are spent.

It should be noted here that innovativeness measured as a willingness to *try out* new ideas, practices, or technologies is not necessarily synonymous with innovativeness as a tendency to *create* new ideas, practices, or technologies. In this study, innovativeness was not quantified in terms of research output, publications, patents, the creation of new practices and procedures within the environment, or similar measures of creative output. Future study could help determine how well correlated measures of innovativeness in terms of trying and in terms of creating innovations are among individuals in research-intensive health care environments and might help explain the apparent paradox of slow diffusion within innovative environments.

It could be argued that, due to the nature of interactive innovations, their adoption by two or more individuals within a social system alone creates one of Schumpeter's (1934) "new combinations" of creative ideas and existing resources, as every use within a social system is unique and represents a change to existing communication processes and systems. Creating and learning new ways of communicating, however, is unlikely to be the primary goal of the work of individuals within health care environments and can instead distract from their primary work, particularly if they find themselves performing "secretarial" or "technical support" duties as a result of adoption, as will be discussed further below. There can be high costs for use for interactive innovations in terms of time and effort, even for those who do enjoy experimenting with new technologies and processes, and even if the innovations do represent a relative

advantage over existing tools and systems. If enough others are not also eventually persuaded to adopt the innovation, this, too, will impact an innovation's value. All of these factors can negatively impact innovation adoption, even for innovative individuals in innovative environments.

As this was a study of the adoption of relatively new innovations by physicians in training, the original design of this study did not anticipate respondents would have experience using the same innovation in a different environment. However, the fact that two of the survey respondents had prior experience with PerfectServe and I-PASS respectively in previous roles helped clarify when factors were not related to innovations or individuals but were rather social and environmental or use-related factors.

Social and Environmental Factors: The Need for New Norms

Internal social and environmental factors that can potentially impact adoption and implementation include use of the innovation by others, internal policies, and availability of technical support and training. In the case of PerfectServe, existing technological infrastructure and the built environment also played a role. For PerfectServe in particular, lack of established social norms around text messaging as a method of communication and differing beliefs about the normative rightness of particular types of messages were a noted source of conflict. External factors influencing adoption and assessment of innovations included external laws and policies, and, for PerfectServe, innovations' impact on residents' and fellows' home lives. Interactive innovations inevitably both impact and are impacted by their social environments. Social and environmental factors may at times be particularly difficult for individual adopters to

control, though negative impacts of social and environmental factors on adoption can potentially be mitigated by individual or organization effort.

At the time of the study, both I-PASS and PerfectServe were still unevenly diffused throughout the medical center. PerfectServe was at a later stage of diffusion than I-PASS, and levels of agreement among survey respondents that *most* people were using PerfectServe were high. However, not everyone was using PerfectServe, and this did increase the costs in terms of time and effort when some colleagues could not be contacted via PerfectServe and information about alternate means of communicating with them was not easily available. Again, the value of an interactive innovation like PerfectServe for particular users is dependent on network externalities, or how many others in the community are using it, as well as how they are using it (Katz & Shapiro, 1986). Reciprocal interdependence between early and later adopters of interactive innovations can make diffusion of innovations complex in typical circumstances, and if others with whom the user communicates do not also eventually adopt the innovation, use is likely to discontinue (Markus, 1987). In this environment, where respondents report use is mandated for some users but not others, the failure of those others to eventually adopt the innovation will not necessarily lead to discontinuation of use among those who are required to use it, even if some find the innovation to be of little value, but may lead to slowdowns in communication, the development of workarounds, or the need to maintain multiple systems of communication, creating additional decision points when information must be shared. The interviewee who had used PerfectServe in a previous position believed that the

other institution's internal policies mandating use of PerfectServe for all physicians and limiting the customization of algorithms greatly improved experiences with the innovation.

Lack of awareness of internal policies governing use of both innovations within this environment is a potential area of concern. Over a third of users were not sure if policies existed governing the sharing of information via PerfectServe, and a large majority who answered a similar question were not sure if such policies existed for I-PASS. Another potential concern is the lack of awareness of internal support for these innovations in the form of training and assistance with questions and technical problems. Some users of PerfectServe had yet another concern related to existing technological infrastructure and the built environment, specifically that wireless connectivity was a problem in certain parts of the hospital, contributing to delays in receiving messages and beliefs that PerfectServe was not the most appropriate medium for time-sensitive communications.

Most communication via the innovations was governed by social norms rather than formal policies. There was some evidence that incompatibility with existing norms impacted adoption of I-PASS, which was seen as violating those norms by requiring users to give too much information during handoffs at times when it was not seen as necessary. For PerfectServe, both incompatibility with existing norms and the lack of existing norms, specifically the lack established social norms around text messaging, impacted adoption. At the time of the study, norms around PerfectServe communications were still being established, and differences in beliefs about the

normative rightness of particular types of text message communications were a potential source of conflict between users and user groups. Residents and fellows reported conflicts and differing practices regarding the type and amount of information it was appropriate to send via text, and whether PerfectServe was an appropriate medium for certain communications, such as those involving acute patient issues. Others questioned the normative rightness of using a texting platform for their work at all, including the interviewee who felt uncomfortable using a communication medium that felt "willy-nilly" to send work-related communications, particularly if those communications were retained for legal purposes, and the survey respondent who was concerned about the potential for patients to misunderstand the nature of the activity when a physician was texting on a personal device in front of them.

The introduction of PerfectServe had not yet resulted in the full replacement of existing communication structures with a new one. The pager system continued to exist and users were required to carry both devices. Many preferred other means of communication, such as voice calls, over PerfectServe, at least in some circumstances. PefectServe *had* created new possibilities for communication and additional points for decision making. This in turn created conflict when groups or users differed in their understanding of what was appropriate or in their possession of knowledge needed to make a decision. The fact that groups interacted with the system via different interfaces potentially contributed to these differences. Future research, perhaps involving further interviews and ethnographic observation, could help determine to what extent new

social norms around communication have been established in the time since the study, and to what extent those norms differ between groups.

While fewer external social and environmental factors were found to have an impact on innovation adoption or assessments, external laws and regulations, particularly the need to comply with external requirements for information protection and security were mentioned, as were the interactions between PerfectServe and respondents' personal and family lives. The latter will be discussed further in the section on values.

Use-Related Factors: The Importance of Considering Contexts

Factors related to the specific uses made of an innovation and the way these uses impact and are impacted by the context(s) of use have not typically been considered as a separate category in diffusion research, but can be especially important for interactive innovations, which are often shaped and reshaped by their actual use in context. This study points to the importance of understanding use-related factors in identifying potential unintended consequences of adoption.

The need to carefully consider all potential use cases and use contexts and the ways these might interact was exemplified in this study by the privacy problems PerfectServe created for users performing sterile procedures. These users could find themselves in a situation where, in the operating room and unable to touch their phone, they were forced to let another individual within the work environment unlock their personal device or risk missing crucial messages. While this was a concern only for certain PerfectServe users at certain times, to those affected it was, in the words of one

interviewee, "a very real issue." This was in addition to other concerns that respondents had about being required to use personal devices for work, including concerns about the entangling of their personal and professional lives, and concerns about a lack of reimbursements for their use of personal data plans and wear and tear and potential damage to their personal phones.

I-PASS was at times rejected because locally developed handoff procedures were seen as more appropriate given the specific nature of users' work. At times, adoption was not considered, because users' work did not involve patient handoffs at all. While one interviewee expressed the belief that most handoffs could probably be adapted to I-PASS with some creativity, in most cases, survey respondents' assessments of their ability to adapt either it or PerfectServe to better meet their own needs or those of others tended to be at the "neither agree nor disagree" midpoint or lower. The specific reasons for these assessments, and to what extent adaptions and changes to the innovations are actually occurring, are other potential areas for future study.

The observability of impacts on the work of the organization was, as expected, another important factor for adoption. Adopters of I-PASS had significantly higher levels of agreement than non-adopters with most statements related to I-PASS's positive impacts on their own work and multiple statements related to I-PASS's impact on work and communication within the medical center. Perhaps most importantly, levels of agreement that use of I-PASS improved patient safety, patient outcomes, and the quality of patient care, were high. Levels of agreement that use of PerfectServe resulted

in these same improvements were nearer the "neither agree nor disagree" midpoint. Levels of agreement with most survey statements related to PerfectServe in this category showed that half or more users did not experience these benefits for their own work and communication as a result of using PerfectServe. In interviewees' responses noting negative impacts of PerfectServe on their own work and workflows, we can see evidence that PerfectServe has colonized or technified the worklife of the organization to some extent, resulting in workflow disruptions, some of loss of social cohesion, and more of residents' and fellows' time and effort being spent in service to the communication system, rather than in pursuit of the goals the communication is meant to accomplish, as was case for the user who felt their duties were becoming "secretarial" when using PerfectServe and that more of their time was being spent performing tech support functions rather than in pursuit of their own learning. In the absence of a clear relationship between use of an innovation and a positive impact on individual or organizational goals and values, adoption can be a much harder sell.

As noted before, one important use-related factor is whether or not use of an innovation is perceived to be voluntary. The majority of PerfectServe users did not feel their own use was voluntary. Perceptions of the voluntariness of use for I-PASS were nearer the midpoint and did not differ significantly between adopters and non-adopters. For PerfectServe especially, users tended to describe their initial encounter with the innovation in terms of being told to use it, often with very little informational context. At the time of the study, adoption of PerfectServe appeared not to constitute full adoption of the innovation (Jeyaraj & Sabherwal, 2008), as some users disagreed that they used

or were familiar with all of PerfectServe's features, and some only used it for particular communication tasks. Trudel et al. (2017) linked lack of use of advanced features to lack of know-why information on the rationales for adoption of an innovation. Results from this study suggest that know-why (reasons for adopting innovations) and know-how (strategies for implementing innovations) are types of knowledge that have not necessarily diffused along with either PerfectServe or I-PASS, and lack of this knowledge has likely impacted innovation implementation to some extent. Again, this represents a potentially rich subject for future research.

The PMIIA as a Whole

Overall, the model as a whole appears to be useful for examining the specific factors that impact innovation adoption in research-intensive health care environments. One of the model's main strengths is that it is context agnostic. It can be used to examine the adoption of multiple types of innovations, not only among other populations in the field of health and medicine, but also potentially among other individuals and organizations with different specialties. The model does not presuppose the strength of impact of any quadrant in a particular adoption scenario, and while it accounts for the probability that quadrants will overlap and impact each other, does not presuppose the strength or direction of these impacts. This proved useful for examining not only the factors that impact adoption in the study, but also where overlap between factors resulted in unintended impacts on information sharing. It was also a useful lens for examining what values were in play in adoption and implementation of the innovations, as discussed below.

Values in Diffusion

Values are an inherent part of the diffusion of innovations; part of Rogers' (2003) definition of an innovation's compatibility is its consistency with the existing values of potential adopters. However, few studies of diffusion have looked explicitly at the role of human values in diffusion and adoption. Values are factors in all four quadrants of PMIIA. They are innovation factors, as both individual and social values inform the design of innovations themselves. They are individual and social and environmental factors, as individual and social values likewise inform adoption decisions. They are use-related factors, as the values in play, the extent to which they are emphasized by particular actors, and potential sources of value conflict may vary by use and use context.

In the present study, the values that informed adoption of innovations were largely professional values. As expected, residents and fellows place a high value on patient health, safety, and lives; patient privacy; information security; and time. Residents and fellows also value their own privacy. This value was violated when physicians who received PerfectServe messages while they were performing sterile procedures had to give someone else access to their personal phone and potentially the personal data stored on it to others. This study looked at professional communication in an environment where individuals in the study population were primarily communicating in their roles as physicians in training. In any study of environments in which information sharing is primarily professional, it can be expected that professional values will play a role in adoption decisions. However, it should be remembered that human actors within

such social systems will also have personal values, and those values will also play a role in innovation adoption and use.

Another value that emerged from the interviews was work/life balance. PerfectServe impacted residents' and fellows' home and personal lives in a number of ways, at times disrupting sleep and the lifeworld of households with messages and message reminders, something that added to respondents' frustrations with misdirected messages. Beyond balance, there were also experiences of personal and professional lives "crossing and entangling" in a way some respondents found unacceptable as the result of having both personal and professional communications mediated by a single device. Sociologists, particularly those studying social media technologies, use the terms "context collapse" or "collapsed contexts" to describe situations in which the maintenance of social roles and social boundaries are complicated by electronic media which blur the boundaries between public and private, and potentially, professional and personal contexts (see boyd, 2008; Davis & Jurgenson, 2014; Marwick & boyd, 2011; Meyrowitz, 1985). While requiring installation of a work-related application on personal devices may represent a cost savings to the organization, and even a convenience to users who do not have physically manage multiple devices, there is evidence here that this requirement does collapse personal and professional contexts in ways that lead to unintended consequences. In addition to the privacy violations already discussed, there were issues around normative rightness that stemmed from using a device and method of information sharing typically associated with less formal social contexts for professional communication, issues with bearing the personal costs of work related use,

and even, as mentioned by one resident, practical issues with potentially forgetting to bring one's phone to work, as it was a device used in everyday life for personal communications and not conceptualized and handled specifically as a work-related object in the same way a pager was.

Values are inputs in the design of any innovation, and as noted in the literature review, professional values vary between disciplines, even if both disciplines have roots in the empirical-analytic sciences. Issues arising from mismatches between the values assumed by an innovation's designers and the values held by its users, and the importance of having user input in the design process, have been noted in situations where designers and users have different areas of expertise. I-PASS, however, is a handoff process designed by physicians for physicians. In this case, the innovation's designers were not exceptionally different from its intended users. However, value clashes were noted, not because the values held by potential users were different from those that informed I-PASS's design, but because the emphasis placed on those values differed. Patient safety and time are both values within this environment. However, some respondents felt that using I-PASS to standardize handoffs would cost them time and prolong handoffs unnecessarily. The benefits in terms of patient safety were not worth this tradeoff, as respondents believed existing procedures were already adequate for safe handoffs. This finding speaks to a need not only to understand what values might be in play in adoption decisions and whether or not innovations are compatible with these values, but also to understand when values might be in conflict, and when

use of an innovation might be perceived to inappropriately emphasize one or more values at the expense of others.

The study of values in the context of diffusion also points to a number of additional areas for future research, in particular the need to understand the structures and mechanisms that determine not only whose and which values are in play within a social system, but whose values matter in innovation adoption decisions and which values are allowed to prevail in instances of value conflict. For example, while many participants within the study did not feel that they were able to make their own choices to adopt innovations, particularly in regards to PerfectServe, this was not the case for everyone within the organization, leading to perceptions of inequalities, such as the perception that, in the words of one respondent, “we'll cater to this person, but not cater to this person” when it came to mandating adoption decisions. Much like values themselves, issues of power and structural inequality in diffusion could be illuminated by studies utilizing the PMIIA model to examine internal and external social and environmental structures, individuals and their roles within those structures, the potential for innovations to reinforce or disrupt existing structures, and the interaction of all of these elements in specific use contexts.

Finally, the experiences of the interviewee who had used I-PASS as a medical student speaks to the importance of explicitly connecting innovation use to core personal and professional values—in this case, the core value of patient safety—during the persuasion phase of innovation diffusion.

Recommendations for Future Areas of Research and Future Innovation Deployments

A number of possibilities exist for future research to expand on the present study, answer the unanswered questions noted above, and further test the model. Below is a list of recommended areas for further study or future consideration when introducing new innovations in the current study environment:

Innovation Introduction

One of the limitations of this study was that both innovations had already been introduced into the environment at the time the study began, and introduction processes could not be directly observed. There is some evidence from this study, however, that crucial information, particularly regarding the reasons for adopting an innovation—information related to Trudel et al.'s (2017) know-why or Kotter's (2012) change vision—had not necessarily been diffused along with innovation itself. Despite the fact that this information was available to and considered by those driving the change, respondents reported their own experiences of being introduced to an innovation as being told to use it, sometimes with very little context or guiding information. Other times respondents did not immediately have information regarding an innovation's features, such as the ability to look people up by name in PerfectServe or how the synthesis phase of I-PASS made it different from existing handoff procedures. Future research, perhaps involving ethnographic observation of innovation introduction at an earlier phase, could help explain these gaps.

Adaption and Reinvention of Innovations

At the time of the study, interview respondents noted that PerfectServe in particular had already been changed and improved within the environment and that future improvements were forthcoming, leading one respondent to describe it as an "ongoing moving target or a work in progress" (Interview 1). Among the desired improvements mentioned by interviewees to address specific challenges noted in Chapter Four are:

- having physicians' pager information available within PerfectServe,
- a non-overridable option to redirect messages when the intended recipient is in the OR,
- an option to redirect urgent messages to a pager, and
- the ability to selectively copy text from one message into a new message.

At the time of this writing, multiple changes to PerfectServe to address some of the user concerns raised in this study were in development or had already been deployed (Epps, 2018; Starnes, 2018). Likewise, additional groups were noted to be using I-PASS and some had adapted the procedure to better meet their own needs (Metheny, 2018). For the innovations in the current study and future innovations, periodic follow up studies can yield important data on the impact of changes and adaptions to innovations and the environment. The follow up study described below as Phase 3 will gather data not only on how adoption and implementation have progressed, but also on how innovations themselves have changed since the data informing this study was collected.

Identification of Innovative Individuals

Evidence from this study suggests that innovative users may be more aware of the impacts of innovations, use of the innovations, and how to seek more information about innovations. Innovative individuals with social influence may be able to serve as opinion leaders—or, assuming enough influence within the organization, as members of Kotter's (2012) guiding coalition—capable of influencing the adoption decisions of others. Social network analysis, a research method described below, can help identify these individuals.

Visibility of Support and Feedback Structures

There is evidence from the current study that some users are unaware or uncertain of the availability of training and support in use of the innovations, do not know whom to contact with questions about the innovations, and may not be aware of existing avenues for feedback. Increasing the visibility of support and feedback structures may improve user experiences.

Social Norms and Decision-Making

Issues related to social norms and decision-making, particularly regarding use of PerfectServe, are complex. At the time of the study, multiple avenues for communication existed within the medical center, and communicating with others required choosing between them. Communication norms were still being established around text messaging. This was complicated by the fact that not everyone was

required to use PerfectServe and PerfectServe users sometimes found locating alternate contact information for non-users difficult.

Beliefs about appropriate methods for communication were found to vary at times between users or user groups, for example between physicians who preferred to be paged with acute or emergent patient issues, and nurses who used PerfectServe for these communications. The determination of what method of communication to use in a particular situation could be standardized with training and formal policies that are consistent across groups. Determining what represents an acute issue, on the other hand, is a different question, and as one interviewee pointed out, one that may require more knowledge and expertise than the sender of a message may possess.

Customization and Voluntariness of Use

Making adoption decisions voluntary allows users to reject an innovation in favor of an existing information system or tool that may better meet their needs. Allowing users to customize innovations may result in it better meeting the needs of individuals or smaller groups within the organization. However, tradeoffs in a lack of standardization and the need for users to spend time and effort learning or choosing between multiple options, or trying and rejecting or reprogramming particular customizations, as evidenced in this study, can create confusion. Finding an appropriate balance may vary by innovation and situation but should be considered when deploying interactive innovations within this environment.

Interactions Between Contexts and Quadrants

The privacy issues created by the installation of the PerfectServe application on personal phones and having users who, while performing sterile procedures, could not touch their own devices points to the need to carefully consider all possible contexts of use and interactions of individuals, innovations, the social environment, and use context which could result in unexpected or unwanted outcomes when new innovations are deployed.

Professional Values

Values in play in adoption and use decisions in the present study were in large part professional ones: patient health and safety, privacy, information security, and time. To some extent, users' information about the innovations did connect to these professional values: PerfectServe's security features were noted positively by most interview respondents, and many were aware of I-PASS as a tool for patient safety. The experience of the interviewee who had encountered I-PASS as a medical student points to the potential benefits of explicitly connecting use of the innovations to these values, if possible with empirical evidence of an innovation's positive impact on core values, if such evidence exists. Adding to the introduction process likely represents a tradeoff in terms of time. As interactive innovations inevitably cost time to learn, use, and assimilate, particularly in the early stages of diffusion, being able to connect use of an innovation to eventual efficiencies or to other professional values could help facilitate its acceptance.

Personal Values

Medical professionals communicating and sharing information within a health care environment are likely doing so in a professional capacity, but human actors within a social system are first and foremost human beings, and their personal values will also impact innovation adoption and communication decisions. Use of personal devices for communication makes it even more likely that personal values will play a larger role in these decisions, and the impacts of these values, as well as impacts of innovation use on adopters' personal lives and well-being should be carefully considered.

Sources and Resolutions of Value Conflict and Structures of Power

As noted previously, another rich area for future research is in determining not only what values are in play, but whose and which values are emphasized or ignored in adoption decisions, as well as how structural inequalities potentially impact diffusion, and the subsequent capabilities of the innovation itself, once adopted, to reinforce or disrupt these structures.

Recommendations for Future Research Methods

The following sections expand on these suggestions to recommend future research and research methodologies:

Phase Three: Follow-Up Interviews

One limitation of the current study is that it captures data on innovation adoption within a single population at a single point in time. A third phase of this research is planned in order to gather additional data about questions emerging from the data from

the first two stages of research, and about changes and developments in innovation use and the innovations themselves since initial research was conducted. This phase consists of qualitative semi-structured interviews with survey respondents who have agreed to participate by responding affirmatively to a question asking if they would like to be contacted for this purpose at the end of the Phase 2 survey, and with members of the study population who will be recruited in a process similar to that used for the Phase 1 interviews. A script with an initial set of questions has been developed, informed by data from the first two phases, and includes questions related to continuing use of the innovations, changes in use of the innovations, changes to the innovations themselves, non-use of the innovations, voluntariness of use, and barriers to adoption. Conduct of interviews and analysis of interview data will be similar to the procedures described for Phase 1 of this study.

Going Beyond Self-Report: Ethnographic Observations and Other Alternatives to Surveys

Another limitation of the study was the low survey response rate. While this was to some extent expected, given that low response rates are common for surveys of physicians, the fact that the survey response rate was under 20% limited analyses that could be conducted and conclusions that could be drawn from the data. While some refinement of survey methods—for example, shortening the length of the instrument to prevent survey fatigue, as was somewhat evident from the data, given the lower number of responses to later questions—could increase response rate, another possibility is to consider alternate research methods that do not utilize surveys for data gathering at all.

This is a highly surveyed population and one in which, as evident this study, members place a high value on their time. Additionally, this method relies on self-report, which may or may match actual use of innovations. Research methods that would allow for more direct observation of innovation use within the environment without requiring participants to give up their time to participate in the research could perhaps be more ideal. Ethnographic observations of innovation use within the work environment is a qualitative method that could yield a good deal of rich data on innovation use in context (Lindlof & Taylor, 2010). This could include where and when innovation use occurs in the context of the work of the organization, as well as how innovations are used to communicate, and who communicates with whom using the innovations. For innovations that are information and communication technologies, combining this with quantitative analysis of computer log files and similar artifacts of ICT use would result in data about actual use of innovations and whether or not this actual use matches users' perceptions (Tai-Seale et al., 2017). While both of these methods have potential advantages to participants in that they allow for data gathering without necessarily requiring participants to set aside time to answer researchers' questions, they do require additional time on the part of the researcher. Ethnographic observation of this population in particular might require a team of trained observers who could potentially be available around the clock to make observations.

Social Network Analysis

A social network is "a structure composed of a set of actors, some of whom are connected by a set of one or more relations" (Knoke & Yang, 2008, p. 8). *Social network*

analysis, which examines the actors, relationships, and structure of existing social networks, is another potential method for further research that can help determine likely patterns of diffusion when innovations are introduced (Knoke & Yang, 2008; Valente, 1995). Social network analysis can determine the shape and structure of networks, provide a picture of who within a social system communicates with whom and via what pathways information is and is not likely to flow, and determine the network positions of both adopters and non-adopters of innovations. It can also help identify potential opinion leaders, capable of influencing on the behavior of others. Analysis of artifacts of ICT use, described in the previous section, can help inform this research.

Models for Predicting Diffusion

One question arising from this research is whether, once patterns of diffusion and barriers to adoption of innovations are known, it would be possible to predict the diffusion of future innovations. Multiple models have been developed and used to mathematically predict innovation diffusion (see Bass, 1969; Bass, Gordon, & Ferguson, 2001; Bass, Krishan, & Jain, 1994; Bass & Norton, 1987; Chu et al., 2010; Daim, Basoglu, Gerdsri, & Tran, 2010; England et al., 2000; Geroski, 2000; Islam, Feibig, & Meade, 2002; Krishnan, Bass, & Kumar, 2000; Mahajan & Peterson, 1985; Meade & Islam, 2010; Van den Bulte and Stremersch, 2004). These models have seldom been used in diffusion research in the health care sector, and an informal survey by Greenhalgh et al. (2005) revealed researcher doubts as to their utility in such highly regulated environments. Additionally, none account for the reciprocal interdependence of past and future users of interactive innovations. However, once data on past diffusion

of innovations is collected and analyzed and the total number of potential adopters within the study population is known, a possible avenue of future research could be to examine whether an existing model can be fitted to the data and potentially used to predict the diffusion of future innovations within the same environment.

Testing the Model with New Innovations, New Populations, and New Environments

As the model is context agnostic, another avenue for future research is to test it in other environments. Other academic medical centers or university hospitals are an obvious choice, as are other types of health care environments. Further research could determine the model's applicability to interactive innovation adoption in other types of research-intensive environments, including universities, research laboratories, corporate R&D departments, and other organizations in which innovation is rewarded, the population of potential adopters is likely to be innovative, and the nature of the information that needs to be communicated, highly specialized. The model would help information researchers to discover and leverage information about innovations, as well as the particular organization, individuals within it, and specific work processes, communication practices, values, and other factors which can help explain and potentially even help predict adoption behaviors and patterns of diffusion.

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APPENDICES

Appendix A: Phase 1 Interview Guide

Items in parenthesis are for interviewer notes only, DO NOT READ to respondent

Introduction: Thank you for agreeing to be part of the study. Before I begin, I would like to transcribe the interview. Is it ok if I record the interview for this purpose? (If no, ask if I can take notes during the interview. If respondent answers no, thank them for their time, and terminate interview.)
I study adoption of innovations in research-intensive environments. The purpose of this interview is to gain a better understanding of residents' perceptions and use of some recent innovations for information sharing and communication at the [medical center]. These interviews will help provide data about the use of recently introduced innovations, as well as residents' perceptions of these innovations and the roles they play in current work and communication practices

Introductory Questions

1. Tell me a bit about yourself and the work that you do here.
2. Who do you communicate with most during a typical work shift? In what ways do you normally communicate with them?

PerfectServe Questions

1. Do you currently use PerfectServe?
    a. (If no) Are you at all familiar with PerfectServe? (If no, proceed to I-PASS questions; if yes, ask questions b and c, then questions 2 and 7-8)
    b. Why aren't you currently using PerfectServe?
    c. Do you anticipate using PerfectServe in the future?
2. How did you first hear about PerfectServe?
3. How was PerfectServe introduced? Were you involved in the introduction of PerfectServe?
    a. (If yes) Were you able to give feedback during this process?
    b. (If yes) How was your feedback sought? How was it used?
4. (If user) How do you typically use PerfectServe?
5. (If user) Do you find PerfectServe easy to use?
6. (If user) Have you ever had any problems using PerfectServe?
    a. (If yes) Have you been able to work around or overcome those problems?
    b. (If yes) How?
7. (If user) Is there anyone you work with who doesn't use PerfectServe? Why?
8. (If user) You mentioned you used PerfectServe for (include use(s) mentioned in question 3). If you could design an ideal communication platform for this, what would it look like?
9. Have you talked others about PerfectServe?
10. If you were considering working for a new organization and found out they were using PerfectServe, would that change your opinion of working for the organization? How?

I-PASS Questions

1. Can you briefly describe your current patient handoff process?

2. (If I-PASS not mentioned) Do you currently use I-PASS?
    a. (If no) Are you at all familiar with I-PASS? (If no, proceed to final question; if yes, ask question b, then questions 3, and 7-9)
    b. Why aren't you currently using I-PASS?
    c. Do you anticipate using I-PASS in the future?
3. How did you first hear about I-PASS?
4. How was I-PASS introduced? Were you involved in the introduction of I-PASS?
    a. (If yes) Were you able to give feedback during this process?
    b. (If yes) How was your feedback sought? How was it used?
5. (If user) Do you find I-PASS easy to use?
6. (If user) Have you ever had any problems using I-PASS?
    a. (If yes) Have you been able to work around or overcome those problems?
    b. (If yes) How?
7. (If user) Is there anyone you work with who doesn't use I-PASS? Why?
8. Have you talked to others about I-PASS?
9. If you could design an ideal system for patient handoffs, what would it look like?
10. If you were considering working for a new organization and found out they were using I-PASS, would that change your opinion of working for the organization?

Final Question

1. Thank you for your time. Before we wrap up, is there anything else you think I should know that I haven't asked?

Appendix B: Innovation Adoption Survey

Innovation Adoption Survey

Start of Block: Default Question Block

You are invited to participate in a research study investigating residents' use of new information and communication practices and technologies at the [this organization]. Your responses will help with a better understanding of how these innovations are being used by residents and whether they meet residents' communication needs. The questionnaire should take about 10-20 minutes to complete, depending on your responses. You will have an opportunity to win a $25 gift card. Your chance of winning the gift card is not dependent on your participation in the survey.
No sensitive items are included in the survey, and your participation poses no foreseeable risks other than those one would encounter in everyday life. Also, your responses will be recorded anonymously so that no one can link your responses to you personally. Your participation in this research is voluntary, and you may decline to participate without risk. While it is useful to be complete in your responses to the survey, you may skip any questions, and you are free to withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you have any questions about the study or procedures, please contact Danielle Pollock (dpolloc2@vols.utk.edu) or her advisor Dr. Suzie Allard (sallard@utk.edu) of the University of Tennessee. If you have questions about your rights as a participant, contact the Office of the Research Compliance Officer (865) 974-7697. If you would like to keep a copy of this consent statement, you can save or print this page. By proceeding to the survey I acknowledge that I have read the above statements, I am 18 years old or older, and I agree to participate.

- ❍ I agree to participate in the survey. (1)
- ❍ I do not agree to participate in the survey. (2)

Skip To: End of Survey If You are invited to participate in a research study investigating residents' use of new informatio... = I do not agree to participate in the survey.

Thinking about your technology use at work and in everyday life, please rate your level of agreement with the following.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
If I heard about a new information technology or practice, I would look for ways to experiment with it. (1)	❍	❍	❍	❍	❍
Among my peers, I am usually the first to try out new information technologies and practices. (2)	❍	❍	❍	❍	❍
In general, I am hesitant to try out new information technologies and practices. (3)	❍	❍	❍	❍	❍
I like to experiment with new technologies and ways of sharing information. (4)	❍	❍	❍	❍	❍

Have you ever heard about PerfectServe?

- ❍ Yes (1)
- ❍ No (2)

Skip To: Q25 If Have you ever heard about PerfectServe? = No

Do you currently use PerfectServe?

- ❍ Yes (1)
- ❍ No, but I have in the past (2)
- ❍ No, never (3)
- ❍ Not sure (4)

Skip To: Q25 If Do you currently use PerfectServe? = No, never

Skip To: Q25 If Do you currently use PerfectServe? = Not sure

Thinking about your experiences using PerfectServe to communicate, please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
PerfectServe is compatible with my work and communication needs. (1)	❍	❍	❍	❍	❍
PerfectServe fits well with the way I like to communicate. (2)	❍	❍	❍	❍	❍
PerfectServe fits well into my work style. (3)	❍	❍	❍	❍	❍
It is easy to get PerfectServe to do what I want it to do. (4)	❍	❍	❍	❍	❍
Overall, PerfectServe is easy to use. (5)	❍	❍	❍	❍	❍
PerfectServe makes sense for the environment in which I work. (6)	❍	❍	❍	❍	❍

Thinking about your experience using PerfectServe to communicate, please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
PerfectServe enables me to communicate and share information more quickly. (1)	❍	❍	❍	❍	❍
PerfectServe improves the quality of communication at [this organization]. (2)	❍	❍	❍	❍	❍
PerfectServe makes it easier to do my job. (3)	❍	❍	❍	❍	❍
PerfectServe enhances my effectiveness. (4)	❍	❍	❍	❍	❍
PerfectServe gives me greater control over my work. (5)	❍	❍	❍	❍	❍

The following questions ask about your introduction to PerfectServe and your use of PerfectServe since that time. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Before using PerfectServe, I was able to try it out. (1)	❍	❍	❍	❍	❍
I was permitted to use PerfectServe on a trial basis long enough to see what it could do. (2)	❍	❍	❍	❍	❍
I am able to make changes and adapt PerfectServe to better fit my work practices. (3)	❍	❍	❍	❍	❍
I am able to make changes and adapt PerfectServe to better meet my own communication needs. (4)	❍	❍	❍	❍	❍
I am able to make changes and adapt PerfectServe to better match the communication practices of the people I work with. (5)	❍	❍	❍	❍	❍

The following questions ask about use of PerfectServe at the [medical center] and at other organizations. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Many people at [this organization] use PerfectServe. (1)	❍	❍	❍	❍	❍
People at [this organization] who use PerfectServe have a high profile. (2)	❍	❍	❍	❍	❍
I am aware of other high profile organizations that use PerfectServe for communication. (3)	❍	❍	❍	❍	❍
Many others in my field working at other organizations use PerfectServe. (4)	❍	❍	❍	❍	❍

The following questions ask about your use of PerfectServe at [this organization]. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Training on how to use PerfectServe is available at [this organization]. (1)	❍	❍	❍	❍	❍
If I have a question about PerfectServe, I know who to ask. (2)	❍	❍	❍	❍	❍
If I have a technical problem with PerfectServe, I know where to get help. (3)	❍	❍	❍	❍	❍
At [this organization], I know many people are using PerfectServe. (4)	❍	❍	❍	❍	❍
PerfectServe is not used very often at [this organization]. (5)	❍	❍	❍	❍	❍

The following questions ask about information shared via PerfectServe. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Information shared via PerfectServe is secure. (1)	❍	❍	❍	❍	❍
PerfectServe protects patient privacy and the confidentiality of patient information. (2)	❍	❍	❍	❍	❍
PerfectServe protects my privacy and the confidentiality of my information. (3)	❍	❍	❍	❍	❍

The following questions ask about your experience using PerfectServe in your current position. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
PerfectServe is compatible with all aspects of the work of [this organization]. (1)	❍	❍	❍	❍	❍
PerfectServe fits well with the way people at [this organization]like to work and communicate. (2)	❍	❍	❍	❍	❍
PerfectServe improves the quality of communication within [this organization]. (3)	❍	❍	❍	❍	❍
PerfectServe increases the amount of information shared within [this organization]. (4)	❍	❍	❍	❍	❍
PerfectServe makes it more difficult to communicate with others at [this organization]. (5)	❍	❍	❍	❍	❍

The following questions ask about your experience with PerfectServe in your current position. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
My administration does not require me to use PerfectServe. (1)	❍	❍	❍	❍	❍
I use all the available features of PerfectServe. (2)	❍	❍	❍	❍	❍
It is easy to adapt PerfectServe to meet my needs when I am performing a specific task. (3)	❍	❍	❍	❍	❍
There are some features of PerfectServe with which I am unfamiliar. (4)	❍	❍	❍	❍	❍
Although it might be helpful, using PerfectServe is not compulsory in my job. (5)	❍	❍	❍	❍	❍

The following questions ask about the impact of PerfectServe on your work and organization. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
PerfectServe has a positive impact on the quality of care I provide. (1)	❍	❍	❍	❍	❍
PerfectServe has a positive impact on patient outcomes. (2)	❍	❍	❍	❍	❍
It is easy to see the impact of PerfectServe on the work of [this organization]. (3)	❍	❍	❍	❍	❍
PerfectServe has a positive impact on the quality of communication at [this organization]. (4)	❍	❍	❍	❍	❍
Use of PerfectServe has improved patient safety. (5)	❍	❍	❍	❍	❍

Does [this organization] have official policies governing the sharing of information via PerfectServe?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Not sure (3)

Skip To: Q35 If Does [this organization]have official policies governing the sharing of information via PerfectServe? = No

Skip To: Q35 If Does [this organization]have official policies governing the sharing of information via PerfectServe? = Not sure

The following questions ask about the policies of [this organization] regarding use of PerfectServe. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
PerfectServe is compatible with [this organization]'s policies on information security. (1)	❍	❍	❍	❍	❍
PerfectServe is compatible with [this organization]'s policies on information privacy and confidentiality. (2)	❍	❍	❍	❍	❍
I feel confident I understand [this organization]'s guidelines for using PerfectServe. (3)	❍	❍	❍	❍	❍
I feel confident I understand the consequences of violating my organization's policies when using PerfectServe. (4)	❍	❍	❍	❍	❍

Is there anything you want to say about PerfectServe that hasn't been asked in this survey?

_____

_____

_____

_____

_____

Have you ever heard about I-PASS?

- ❍ Yes (1)
- ❍ No (2)

Skip To: Q41 If Have you ever heard about I-PASS? = No

Do you use currently the I-PASS handoff procedure?

- ❍ Yes (1)
- ❍ No, but I have in the past (2)
- ❍ No, never (3)
- ❍ Not sure (4)

Skip To: Q41 If Do you use currently the I-PASS handoff procedure? = Not sure

Skip To: Q41 If Do you use currently the I-PASS handoff procedure? = No, never

Thinking about your experience using I-PASS to communicate during handoffs, please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I-PASS enables me to communicate and share information more quickly. (1)	❍	❍	❍	❍	❍
I-PASS improves the quality of communication during handoffs. (2)	❍	❍	❍	❍	❍
I-PASS makes it easier to do my job. (3)	❍	❍	❍	❍	❍
I-PASS enhances my effectiveness. (4)	❍	❍	❍	❍	❍
I-PASS gives me greater control over my work. (5)	❍	❍	❍	❍	❍

Thinking about your experience using I-PASS to communicate during handoffs, please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I-PASS is compatible with my work and communication needs. (1)	❍	❍	❍	❍	❍
I-PASS fits well with the way I like to communicate. (2)	❍	❍	❍	❍	❍
I-PASS fits well into my work style. (3)	❍	❍	❍	❍	❍
Overall, I-PASS is easy to use. (4)	❍	❍	❍	❍	❍
I-PASS makes sense for the environment in which I work. (5)	❍	❍	❍	❍	❍

The following questions ask about your introduction to I-PASS and your use of I-PASS since that time. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Before using I-PASS, I was able to try it out. (1)	❍	❍	❍	❍	❍
I was permitted to use I-PASS on a trial basis long enough to see what it could do. (2)	❍	❍	❍	❍	❍
I am able to make changes and adapt I-PASS to better fit my work practices. (3)	❍	❍	❍	❍	❍
I am able to make changes and adapt I-PASS to better meet my own communication needs. (4)	❍	❍	❍	❍	❍
I am able to make changes and adapt I-PASS to better match the communication practices of the people I work with. (5)	❍	❍	❍	❍	❍

The following questions ask about use of I-PASS at [this organization] and at other organizations. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Many people at [this organization] use I-PASS. (1)	❍	❍	❍	❍	❍
People in at [this organization] who use I-PASS have a high profile. (2)	❍	❍	❍	❍	❍
I am aware of other high profile organizations that use I-PASS. (3)	❍	❍	❍	❍	❍
Many others in my field working at other organizations use I-PASS. (4)	❍	❍	❍	❍	❍

The following questions ask about your use of I-PASS at [this organization]. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Training on how to use I-PASS is available at [this organization]. (1)	❍	❍	❍	❍	❍
If I have a question about I-PASS, I know who to ask. (2)	❍	❍	❍	❍	❍
At [this organization], I know many people are using I-PASS. (3)	❍	❍	❍	❍	❍
I-PASS is not used very often in my organization. (4)	❍	❍	❍	❍	❍

The following questions ask about information shared using I-PASS. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Information shared using I-PASS is secure. (1)	❍	❍	❍	❍	❍
Patient information shared using I-PASS is private and confidential. (2)	❍	❍	❍	❍	❍

The following questions ask about your experience using I-PASS in your current position. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I-PASS is compatible with all aspects of the work of [this organization]. (1)	❍	❍	❍	❍	❍
I-PASS fits well with the way people at [this organization] like to work and communicate. (2)	❍	❍	❍	❍	❍
I-PASS improves the quality of communication during handoffs within [this organization]. (3)	❍	❍	❍	❍	❍
I-PASS increases the amount of information shared during handoffs within [this organization]. (4)	❍	❍	❍	❍	❍
I-PASS makes it more difficult to communicate with others at [this organization]. (5)	❍	❍	❍	❍	❍

The following questions ask about your experience with I-PASS in your current position. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
My administration does not require me to use I-PASS. (1)	❍	❍	❍	❍	❍
It is easy to adapt I-PASS to meet my needs. (2)	❍	❍	❍	❍	❍
Although it might be helpful, using I-PASS is not compulsory in my job. (3)	❍	❍	❍	❍	❍

The following questions ask about the impact of I-PASS on your work and organization. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I-PASS has a positive impact on the quality of care I provide. (1)	❍	❍	❍	❍	❍
I-PASS has a positive impact on patient outcomes. (2)	❍	❍	❍	❍	❍
It is easy to see the impact of I-PASS on the work of [this organization]. (3)	❍	❍	❍	❍	❍
I-PASS has a positive impact on the quality of communication during handoffs at [this organization]. (4)	❍	❍	❍	❍	❍
I-PASS has improved patient safety. (5)	❍	❍	❍	❍	❍

Does [this organization] have official policies governing use of I-PASS?

- ❍ Yes (1)
- ❍ No (2)
- ❍ Not sure (3)

Skip To: Q41 If Does [this organization]have official policies governing use of I-PASS? = No

Skip To: Q41 If Does [this organization]have official policies governing use of I-PASS? = Not sure

The following questions ask about your use of I-PASS at [this organization]. Please rate your level of agreement with the following statements.

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
I-PASS is compatible my organization's policies on information security. (1)	❍	❍	❍	❍	❍
I-PASS is compatible with my organization's policies on information privacy and confidentiality. (2)	❍	❍	❍	❍	❍
I feel confident I understand my organization's guidelines for using I-PASS. (3)	❍	❍	❍	❍	❍
I feel confident I understand the consequences of violating my organization's policies when using I-PASS. (4)	❍	❍	❍	❍	❍

Is there anything else you want to say about I-PASS that hasn't been asked in this survey?

_____

_____

_____

_____

_____

Are you a...?

- ❍ Resident (1)
- ❍ Fellow (2)
- ❍ Other (3) _____

What is your residency or fellowship program?

- ❍ Anesthiology (1)
- ❍ Family Medicine (2)
- ❍ Internal Medicine (3)
- ❍ Obstetrics & Gynecology (4)
- ❍ Pathology (5)
- ❍ Radiology (6)
- ❍ General Surgery (7)
- ❍ Urology (8)
- ❍ Other (9) _____

What in what year of your program are you?

- ❍ First (1)
- ❍ Second (2)
- ❍ Third (3)
- ❍ Fourth (4)
- ❍ Fifth (5)
- ❍ Other (6) _____

What is your year of birth?

_____

What is your gender?

- ❍ Female (1)
- ❍ Male (2)
- ❍ Other (3) _____

Appendix C: List of Abbreviations

ANT: Actor-Network Theory

EMR: Electronic medical record

HIPAA: Health Insurance Portability and Accountability Act

ICT: Information and communication technology

IT: Information technology

OR: Operating room

PMIIA: Pollock Model of Interactive Innovation Adoption

Appendix D: Glossary of Terms

Active dissemination: Diffusion which is planned, formalized and hierarchical. (Greenhalgh et al. 2005)

Adoption: The decision to make full use of an innovation as the best course of action available. (Rogers, 1986)

Adopters: Those individuals who had decided, at the time of the study, to make full or partial use of an innovation as the best course of action available (see Rogers, 1986).

Communication: A process in which participants create and share information with one another in order to reach a mutual understanding. (Rogers, 2003)

Communication channel: The means by which messages get from one individual to another. (Rogers, 2003).

Community: A group of individuals with some common interest and stronger communication flows within than across its boundaries. (Markus, 1987)

Compatibility: The degree to which an innovation is perceived as being consistent with existing values, past experiences, and needs of potential adopters. (Rogers, 2003)

Complexity: The degree to which an innovation is perceived as difficult to understand and use. (Rogers, 2003)

Diffusion: The process in which an innovation is communicated through certain channels over time by members of a social system. (Rogers, 2003)

Ease of use: Reverse of complexity (see Rogers, 2003). The degree to which an innovation is perceived as easy to understand and use.

Individual factors: Factors impacting innovation adoption related to an individual capable of making adoption decisions. Depending on which level the study of adoption takes place, individual factors might relate to persons or organizations.

Innovation: 1. An idea, practice, or object that is perceive as new by an individual or other unit of adoption. (Rogers, 2003) 2. The realization of "new combinations" of creative ideas and existing resources (Schumpeter, 1934)

Innovation factors: Factors impacting innovation adoption related directly to the innovation itself.

Innovativeness: 1. The degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system. (Rogers, 2003)

2. (Personal innovativeness) The willingness of an individual to try out any new information technology. (Agarwal & Prasad, 1998) 3. (Organizational innovativeness) The ability of an organization to orchestrate the development of new goods and services. (Styhre & Börjesson, 2006)

Innovators: The first 2.5% of individuals in a social system to adopt an innovation. (Rogers, 2003)

Interactive innovation: An innovative information practice or technology meeting Markus's (1987) definition of an interactive medium, or a "vehicle that enables and constrains multidirectional communication flows among the members of a social unit with two or more members."

I-PASS: A verbal mnemonic meant to standardize communication between residents during transitions in patient care, or handoffs. (Starmer et al, 2012) The five letters of the acronym stand for Illness severity, Patient summary, Action list, Situation awareness and contingency planning, and Synthesis by receiver

Lifeworld: The set of beliefs, practices and structures of communication shared by a particular community; the means by which social integration is produced and reproduced via communicative action. (Habermas, 1987)

Network externalities: The positive effects that additional users and uses of innovations have on the value of those innovations. (from Katz & Shapiro, 1986)

Non-adopters: Those individuals who had decided, at the time of the study, not to make full or partial use of an innovation as the best course of action available (see Rogers, 1986).

Normative rightness: The appropriateness of a speech act given existing social norms. (Habermas, 2001)

Norms: Established behavior patterns, that influence communications within social system. (Rogers, 2003)

Observability: The degree to which the results of an innovation are visible to others. (Rogers, 2003)

Opinion leader: Individual within a social network capable of influencing the attitudes and behaviors of others (Rogers, 2003)

PerfectServe: A commercial, secure health care communication, collaboration, and call management platform. (PerfectServe, n.d.) Includes, but is not limited to, a smartphone application that allows for secure text messaging between medical practitioners.

Reciprocal interdependence: In diffusion, when the behaviors of early adopters are influenced by the behavior of later ones and vice versa. (Markus, 1987).

Relative advantage: The degree to which an innovation is perceived as better than the idea it supersedes (Rogers, 2003)

Research-intensive organization: An organization for which research and development represent major activities and the production of new ideas and new innovations, major outputs.

Slack: The time and resources needed to test innovations, make adjustments, and incorporate them into work practices. (Berwick, 2003; Greiver et al., 2011)

Social and environmental factors: Factors impacting innovation adoption that are related to the larger social environment in which adoption decisions take place. Includes both *internal factors,* or those specific to the environment in which adoption decisions are made, and *external factors,* social and environmental factors which external to the immediate environment, but which impact information sharing and communication within it.

Social system: A set of interrelated units that are engaged in joint problem solving to accomplish a common goal. (Rogers, 2003)

Time: 1. a dimension of, a) the innovation-diffusion process through which a decision-making unit moves from first knowledge of an innovation to confirmation of the decision to adopt or reject it; b) innovativeness, or the degree to which a unit is relatively earlier in adopting innovations than other members of a social system, and, c) the innovation's rate of adoption by members of a social system. (Rogers, 2003). 2. The continued progress of existence as affecting people and things (Oxford English Dictionary); often a valuable and scarce resource in time and medicine.

Trialability: The degree to which an innovation may be experimented with on a limited basis. (Rogers, 2003)

Use-related factors: Factors impacting innovation adoption related to the specific uses made of the innovation and the way these uses impact and are impacted by the context(s) of use.

Value: Refers to what a person or group of people consider important in life. (Friedman, Kahn, & Borning, 2009)

Visibility: Refers to the observability, or visibility, of the innovation's actual use and users within an organization. (Moore & Benbasat, 1991)

VITA

Danielle Elaine Pollock holds a master's degree in Information Science & Learning Technologies from the University of Missouri, Columbia and a bachelor's degree in English from the University of Houston. Her work focuses on the drivers and consequences of changes in information behavior in research-intensive communities. Her areas of interest include innovation adoption in health care, scientists' changing data practices, interdisciplinary collaboration, and the information needs of emerging research communities. Prior to entering the doctoral program at the University of Tennessee, she had a career in libraries spanning several years, during which she held positions at organizations including Sandia National Laboratories, the Missouri Department of Transportation, and the University of Missouri.