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Designing Cost-Effective Telemedicine Camps for Underprivileged Individuals in Less Developed Countries: A Decomposed Affordance-Effectivity Framework

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Abstract

Free telemedicine camps (telecamps) are emergent joint initiatives of healthcare organizations, national and local governments, and not-for-profit nongovernmental organizations (NGOs) with the goal of alleviating the health divide for underprivileged individuals in rural areas of less developed countries. Our study seeks to understand the effectiveness of physician-patient communication at telecamps with several salient characteristics: rural underprivileged patients, physicians in remote cities, and frugal telemedicine technology—specifically, videoconferencing—deployed in Hospitals on Wheels and appropriated by *operators*. We adopt a multiple-actor perspective, propose a decomposed affordance-effectivity framework, and combine variance and process perspectives to examine the phenomenon of interest. We collaborated with Apollo Hospitals, a leading hospital system in India, and collected multisource data from two major telecamps in rural South India. Based on an analysis of survey data from 216 telecamp participants through a variance perspective, we found support for the fit of patient-perceived media richness with two contingency factors—(1) disease diagnostic complexity and (2) patient healthcare needs fulfillment—in influencing patient satisfaction with teleconsultation. Based on an analysis of 46 sessions of teleconsultation video archives through a process perspective, we found that technology appropriation is realized through verbal and nonverbal communication events between patients and physicians, with on-site operators playing multiple roles that serve as "compensatory user effectivity." Our findings yield theoretical and practical implications for how effective telemedicine encounters using frugal technologies can be designed in combination with other cost-effective support personnel resources to broaden healthcare access for underprivileged individuals in less developed countries and, more broadly, to actualize technology affordances in use situations involving multiple actors.

Keywords: Affordance Actualization, Physician-Patient Communication, Underprivileged Patients, Variance Perspective, Process Perspective, Mixed Methods

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1 Introduction

Free health camps[1] and telemedicine[2] are emergent initiatives being used by hospitals, governments, and nongovernmental organizations (NGOs) to alleviate the health divide and broaden access to healthcare services among underprivileged individuals (Khanna, Rangan, & Manocaran, 2006; Kumar, 2010; Latifi, 2004). The Apollo Telemedicine Networking Foundation (ATNF) in India was among the first to host free telemedicine camps (hereafter, telecamps) by leveraging the mobility of free health camps and cost-effective teleconsultation services to connect underprivileged patients with physicians in remote cities and even other countries. Hospitals on Wheels (HoWs) transport videoconferencing equipment to telecamps and establish connectivity with remote physicians. On-site operators (hereafter, operators) are typically well aware of the technological challenges in rural areas and are knowledgeable of multiple actors' languages (e.g., patients' vernacular and physicians' medical jargon) used at telecamps. While such telecamps have the potential to expand access to quality healthcare services, the fragile infrastructure in rural areas together with mixed and complex disease conditions, low literacy rates, and a lack of health awareness among underprivileged individuals complicate communication between physicians and patients, thereby hampering effective use of telemedicine in less developed countries.

Our research objective is to investigate physician-patient communication in the unique telecamp context, which includes underprivileged patients, multiple actors (i.e., patients, physicians, and operators) in the teleconsultation processes, and frugal technology deployed on HoWs. For more than a decade, physician-patient communication has been identified as an "unexpected barrier" for teleconsultation (Paul, Pearlson, & McDaniel, 1999, p. 287; Serrano & Karahanna, 2016). Information systems (IS) scholars have investigated different types of teleconsultation settings through different lenses, including (1) virtual team collaboration with multiple physicians at different locations (Paul, 2010; Paul & McDaniel, 2004); (2) physician-patient dyadic communication through the task-technology fit lens (Serrano & Karahanna, 2016; Yan, Guo, & Vogel, 2013); and (3) synchronized/unsynchronized consultation and distance education with new institutional theory (Miscione, 2007). Scholars in the medical field have largely examined the first type of teleconsultation settings (i.e., physicians' virtual communication from multiple locations without patients' presence) using either quantitative or qualitative methodological approaches (Miller, 2001), but very few have taken a mixed-method approach, as suggested by IS scholars (Ågerfalk, 2013; Venkatesh, Brown, & Bala, 2013). Furthermore, the majority of the studies on telemedicine have been conducted in developed countries. Hence, the IS and medical informatics literature offer limited understanding about the effectiveness of physician-patient communication in our telecamp context.

We turn to the affordance lens from ecological psychology as it establishes a *relational* view between users and a technology artifact, which is suitable for understanding multiple actors' use of videoconferencing technology in the telecamp context. The affordance lens emphasizes the tension between environmental features and human behaviors, with the environment providing affordance opportunities and humans possessing the ability to actualize the affordances (Chemero, 2003; Kadar & Shaw, 2000; Reed, 1989; Stoffregen, 2000, 2003; Turvey, 1992; Warren, 1984). On the one hand, frugal technologies provide affordance opportunities for physician-patient communication in the telecamp context. As such, affordance opportunities have to be perceived by actors and are likely to become more or less salient based on actor and task needs during affordance actualization (Michaels, 2003; Kadar & Shaw, 2000; Shaw, 2001), a variance perspective is required to understand actors' responses to affordance opportunities. On the other hand, affordance

[1] Well-known free health camps include Aravind Hospital's eye camps (aravind.org), Dr. Mohan's diabetes camps (drmohansdiabetes.com), and Narayana Hrudayalaya's cardiac diagnostic camps (narayanahealth.org). The sponsoring hospitals usually operate with a "hybrid revenue model" and segment customers into free and paying groups (Esposito, Kapoor, & Goyal, 2012, p. 532). Hospitals bring medical equipment and healthcare personnel to communities or places where special interest groups can easily be reached (e.g., schools, nursing homes, and rural villages). The camps often last one to two days, during which preliminary diagnoses and/or screening tests are provided. Patients diagnosed with certain diseases are then taken to specialized clinics or hospitals in remote cities for further treatment or surgery.

[2] Telemedicine is another popular initiative that has been implemented in many developing countries (Latifi, 2004; Wootton et al. 2009). Telemedicine broadly refers to the use of information technologies as virtual channels to provide long-distance clinical consultation services and healthcare education (Paul et al., 1999; Whitten & Sypher, 2006). The implementation of telemedicine systems can be very complicated and often involves considerable funding support from NGOs and local governments to build the technical infrastructure and geographically dispersed telemedicine clinics and/or medical learning centers required (Constantinides & Barrett, 2006; Latifi et al., 2009; Nicolini, 2009). Telemedicine services can be understood as the use of cost-effective videoconferencing technology to allow patients to talk with physicians in remote cities and receive synchronized consultation services through the virtual channels.

actualization involves multiple actors (including underprivileged patients, remote physicians, and on-site operators) in the physician-patient communication process. This calls for a process perspective to understand the goal-directed progression of multiple actors' actions (Bernhard, Recker, & Burton-Jones, 2013; Pozzi, Pigni, & Vitari, 2014; Seidel, Recker, & Brocke, 2013).

IS scholars have used the affordance lens to understand usage behaviors of traditional media technologies and a range of novel technologies through variance and process perspectives. With a *variance perspective*, affordances have been viewed as technology functions or capabilities (Goh, Gao, & Agarwal, 2011; Majchrzak, Wagner, & Yates, 2013; Nan & Lu, 2014; Treem & Leonardi, 2012). While technology affordances as functions or capabilities imply action possibilities (Greeno, 1994; Kadar & Shaw, 2000; Michaels, 2003; Warren, 1984), in affordance actualization, technology affordances need to be perceived and interpreted by users and further interact with contingent user and task needs to achieve "fit" (Goodhue, 1995; Michaels, 2003; Kadar & Shaw, 2000). With a *process perspective*, technology appropriation has been viewed as a user's series of goal-oriented actions to actualize technology affordances in concrete-use situations (Markus & Silver, 2008; Poole & DeSanctis, 2004; Strong et al., 2014). Although variance and process perspectives can be complementary in understanding a phenomenon (Newman & Robey, 1992; Sabherwal & Robey, 1995), very few studies in the IS field have combined them, thereby constraining the development of an in-depth understanding of effective technology use in particular situations.

Given the unique characteristics of physician-patient communication in teleconsultation at telecamps, we adopt a multiple-actor perspective, combine variance and process perspectives (Newman & Robey, 1992, Sabherwal & Robey, 1995), and develop *a decomposed affordance-effectivity framework* to investigate the phenomenon of interest. Through a variance perspective, we examine the fit of patient-perceived media richness (i.e., technology affordance for physician-patient communication) with two contingencies that impact patient satisfaction (actualized affordance of the technology): (1) disease diagnostic complexity (task needs), and (2) patient healthcare needs fulfillment (user needs). Through a process perspective, we analyze multiple actors' goal-oriented actions with a particular focus on operators' facilitative roles, which are core to appropriating the videoconferencing technology and actualizing its affordance at telecamps. We collaborated with Apollo Hospitals, a leading hospital system in India, and collected multisource data (patient surveys and teleconsultation video archives) from two major free telecamps at two different locations in rural South India. We applied both qualitative and quantitative methods for data analysis (ordinary least squares [OLS] regression, process analysis, and nonparametric statistics). Our findings reveal that the impact of patient-perceived media richness on their satisfaction with telemedicine services at telecamps is contingent upon disease diagnostic complexity and patient healthcare needs fulfillment. Additionally, our findings show that operators' facilitative roles serve as "compensatory user effectivity" in realizing the affordance of the videoconferencing technology at telecamps. Our findings also yield insights for policy makers and hospital management in less developed countries regarding the role of technology interventions to address the thorny societal issue of the health divide (Sein & Harindranath, 2004).

2 Free Telecamps in Less Developed Countries

Free telecamps, which leverage the advantages of free health camps and telemedicine services (including frugal and simple videoconferencing technology, technology connectivity, and mobile equipment and personnel), have been suggested as one of the best *potential* solutions for broadening healthcare access among underprivileged individuals in rural areas of less developed countries (Khanna et al., 2006; Kumar, 2010; Latifi, 2004). As summarized in Table 1, the "hostile infrastructure" in rural areas of less developed countries is characterized by poor technological connectivity, fragmented transportation systems, and inadequate professional healthcare facilities, including a severe deficit of qualified medical personnel (Martìnez et al., 2004; Prahalad, 2006, p. 42; Venkatesh & Sykes, 2013). HoWs equipped with frugal videoconferencing and supportive technologies, such as backup power generators, are potential means of combatting these adverse infrastructure conditions and address the need to broaden healthcare access among underprivileged individuals (see Appendix A for additional details).

Underprivileged individuals suffer from low literacy rates, earn low and unstable incomes, and often lack awareness of their health conditions (Venkatesh et al., 2016) (Table 1). Hence, healthcare services for these individuals must be cost effective and easy to access and use. In addition, underprivileged individuals who are likely to visit telecamps may have a variety of disease conditions that differ in diagnostic complexity. Since these individuals may vary in terms of their basic health and access to healthcare resources, as well as their awareness and concern about health conditions, they have different healthcare fulfillment needs.

Table 1. Contextualizing Telemedicine at Free Telecamps in Less Developed Countries

Characteristics of rural areas of less developed countries	Characteristics of telemedicine services at free telecamps
Infrastructure • Low technological and internet connectivity • Poor transportation systems • Few healthcare facilities	**Technology and complementary facilities** • HoW configured for teleconsultation sessions • Frugal videoconferencing technology in HoW • Power generators supporting HoW operations
Socioeconomic situation • Low literacy rates • Low and unstable incomes **Health conditions** • Lack of awareness of one's own health conditions • Diseases that differ in diagnostic complexity • Varying healthcare needs fulfillment	**Actors** • Physicians (service providers) are located in remote cities and other countries • Operators (facilitators) staff HoW, arrange teleconsultation sessions at local sites, provide contextual knowledge for HoW operations, and facilitate physician-patient communication • Patients (service consumers) have a lack of awareness of their health conditions, diseases differing in diagnostic complexity, and varying healthcare needs fulfillment

Figure 1. Actors Involved in Teleconsultation at Telecamps

Therefore, communication between physicians and patients at telecamps requires considerable contextual facilitation from on-site operators. Operators who have been trained as franchisees of telemedicine clinics in these areas are experienced in technological operations at local sites and are skilled at communicating using the languages of the multiple actors involved. Operators "break down barriers to communication" by interpreting patients' vernacular and explaining physicians' medical jargon and help realize "process innovation" in the effective delivery of telemedicine services to underprivileged individuals (Prahalad, 2006, pp. 37-38, 103). Figure 1 depicts the actors involved in teleconsultation at telecamps. Videoconferencing is the core frugal technology used to deliver teleconsultation services at telecamps. The service delivery process in the virtual channel involves not only physicians as service providers and patients as service consumers but also on-site operators as facilitators.

3 Theoretical Development

In this section, we review the literature on physician-patient communication in telemedicine, introduce the affordance lens and its application for understanding usage behaviors of traditional media and novel technologies, and propose a decomposed affordance-effectivity framework that adopts a multiple-actor perspective and combines variance and process perspectives to understand the effective use of videoconferencing at telecamps.

3.1 Synthesis of the Literature on Physician-Patient Communication in Telemedicine

IS Literature: We identified a handful of IS studies that have examined physician-patient communication in telemedicine. For example, Paul and colleagues examined teleconsultation[3] as virtual collaboration (among physicians from different locations) using various theoretical perspectives, including knowledge management (Paul, 2006, 2010), sensemaking (Paul, 1999), and technology adoption (Paul et al., 1999, Paul & McDaniel, 2004). Paul et al. (1999) observed that although scholars have assumed audio transmission quality to be satisfactory in most teleconsultation settings, it has turned out to be an "unexpected barrier" to effective telemedicine consultation: "The audio transmission was judged as substandard or unacceptable when a large room or more than three

[3] Different from our mobile telecamps, the type of teleconsultation examined in this work typically involved multiple physicians from different locations, and the patients were not always present during the communication processes (Paul et al., 1999; Paul, 2010).

people were involved in a teleconsult or if the patient had an accent" (Paul et al., 1999, p. 287).[4] Yan et al. (2013) applied the technology-organization-environment (TOE) framework and the task-technology fit perspective and used the case study method to examine virtual collaboration in teleconsultation. Their findings surfaced the importance of aligning interests among stakeholders and achieving fit between diagnostic tasks and the characteristics of videoconferencing technology. Serrano and Karahanna (2016) also used the task-technology fit perspective but integrated it with compensator adaptation theory from evolutionary psychology (Kock, 2004, 2005) to examine physician-patient communication in teleconsultation. Applying a mixed-methods approach combining a qualitative field study with surveys and lab experiments, they found that user and technology capabilities operate as substitutes in influencing task performance.

Medicine/medical informatics literature: To identify relevant articles in medical and medical informatics journals that have investigated telemedicine and physician-patient communication in telemedicine or in other consultation contexts, we reviewed leading medical and medical informatics journals, including the *Journal of the American Medical Informatics Association*, *Journal of Medical Internet Research*, *Journal of the American Medical Association*, and *New England Journal of Medicine*, as well as the MedLine database.

Past work has examined a range of issues related to teleconsultation, including telemedicine system implementation (e.g., Kummervold et al., 2012; Mars & Scott, 2012; May et al., 2003; Zanaboni & Lettieri, 2011); telemedicine as a tool for medical education (e.g., Demiris, 2003; Nicolaidou et al., 2015; Pathipati, Azad, & Jethwani, 2016); and telemedicine applications in developed countries or regions (e.g., United States: Shea et al., 2009 and Palmas et al., 2010; Europe: Muller, Alstadhaug, & Bekkelund, 2016 and Orozco-Beltran et al., 2017) and in less developed countries (e.g., Peru: Miscione, 2007; Botswana: Tesfalul et al., 2016; India: Ganapathy et al., 2016; and Iraq: Patterson et al. 2007). It has also considered the use of telemedicine for various health conditions, for example, cancer (van den Brink et al., 2007), diabetes (Ming et al., 2016; Shea et al., 2009; Palmas et al., 2010), and oral health problems (Tesfalul et al., 2016). In addition, past work has examined how teleconsultation can leverage technological advances, such as cloud-based telemedicine (Liu et al., 2015; Estai et al., 2016), mobile applications (Zhang et al., 2016; Jiang, Zhuang, & Chiu, 2017), and virtual reality integration (Page, 2013).

In quantitative studies, patient satisfaction has been employed as an important outcome variable to capture patients' overall cognitive and affective appraisals of their experiences with teleconsultation services in the general telemedicine context (Agha, Roter et al., 2009; Bakken et al., 2006). In qualitative studies, researchers have analyzed verbal and nonverbal information exchange through observations, case reports, archived resources, and content analysis to understand the effectiveness of physician-patient communication (Agha, Schapira et al., 2009; Miller, 2001; Miller & Nelson, 2005).

Based on our review, we observe that the literature has not addressed two important issues pertaining to telemedicine in a telecamp context: (1) factors affecting patient satisfaction in a context characterized by low literacy rates among patients, highly constrained access to healthcare services, limited awareness of one's own health conditions, multiple local languages, and frugal technologies deployed on HoWs, along with unstable power connections and limited bandwidth (Prahalad, 2006; Venkatesh & Sykes, 2013; Venkatesh et al., 2014); and (2) processes of verbal and nonverbal information exchange among the actors (i.e., physicians, patients, and operators) involved in teleconsultation sessions.

3.2 Rationale for Employing the Affordance Lens from Ecological Psychology

Next, we introduce the affordance lens and discuss how and why we use it given our research objectives. The affordance lens originates in ecological psychology, which focuses on the relationships between animals' abilities and environmental situations (Chemero, 2003; Kadar & Shaw, 2000; Reed, 1989; Stoffregen, 2000, 2003; Turvey, 1992; Warren, 1984). We focus on four elements of the affordance lens and use two simple running illustrations—namely, a chimp's use of a stick to knock down a banana from a tree and individuals' use of a technology in a given situation.

First, the affordance lens differentiates between *affordance perception* and *affordance actualization*. Affordance perception pertains to potential actions that an actor perceives as possible (Chemero, 2003; Greeno, 1994; Kadar & Shaw, 2000). Affordance actualization entails both an affordance and an actor's effectivity (Michaels, 2003). For example, the chimp must first perceive that the stick can be used to knock down a banana from a tree (i.e., perceived affordance of the stick) and then engage in the action of using the stick to knock down the banana (i.e., affordance actualization).

[4] Paul's studies primarily used qualitative methods like case studies (Paul et al., 1999; Paul, 1999, 2006, 2010), with one study using a combination of qualitative and quantitative methods (Paul & McDaniel, 2004).

Similarly, users must perceive that a technology is capable of supporting some task and then engage in corresponding usage behaviors to actualize the perceived affordance. Although IS scholars have found affordance perceptions to vary across technology contexts and user goals (Bernhard et al., 2013; Pozzi et al., 2014; Seidel et al., 2013), "the link, and distinction, between perception (being aware of the existence of an action possibility) and actualization (turning possibility into action) of affordances is still unclear in the IS literature" (Bernhard et al., 2013, p. 7).

Second, the affordance lens suggests that actors' effectivity plays an important role in affordance actualization; in other words, affordance actualization entails the dual aspects of affordance and effectivity (Michaels, 2003; Kadar & Shaw, 2000; Sanders, 1997; Shaw, 2001). Effectivity refers to capabilities that complement environmental affordance situations (Stoffregen, 2003; Turvey, 1992). Back to the running example, the chimp's capability in using the stick to knock down a banana complements the affordance of the stick for knocking down the banana hanging on a tree. The concept of actor effectivity has been appropriated by IS researchers to advance the concept of user effectivity, which refers to user capabilities to use the technology to accomplish a task (Bernhard et al., 2013; Jones, 2003; Markus & Silver, 2008; Pozzi et al., 2014; van Osch & Mendelson, 2011).

Third, the affordance lens underscores the significance of actors' needs in affordance actualization (Michaels, 2003; Kardar & Shaw, 2000; Shaw, 2001). As Michaels (2003, p. 145, emphasis added) noted, "an affordance is the action needed to satisfy some *need*." Actualization of environmental affordances varies depending on the particular needs to be satisfied (Gibson, 1977). For instance, the chimp's affordance actualization of the stick depends on the chimp's needs (e.g., hunger) as well as the chimp's task (e.g., the branch could be too high for the chimp to reach). In the case of IS use, needs may arise from either users or tasks; the needs of users/tasks interplay with technology affordances and contribute to affordance actualization.

Fourth, the affordance lens also suggests that while an affordance stands for an opportunity for action, it is actualized through a series of actions with an orientation toward some specific goal (Michaels, 2003; Karda & Shaw, 2000). The goal of obtaining the banana for a meal guides the chimp's actions of walking to the stick lying on the ground, picking up the stick, holding up the stick, and then knocking down the banana on the tree. IS scholars have also emphasized "goal-oriented action" when investigating technology use through the affordance lens (Goh et al., 2011; Leonardi, 2011, 2013; Markus & Silver, 2008, p. 622; Strong et al., 2014).

3.3 Application of the Affordance Lens in the Extant IS Literature

Following the above insights from ecological psychology, affordance actualization in a technology-use situation needs to be understood according to two different viewpoints: (1) the fit of technology affordance with user needs and task needs, *and* (2) users' appropriation actions. IS scholars have employed the affordance lens and concepts such as appropriation to understand usage behaviors of traditional media (Dennis, Wixom, & Vandenberg, 2001; Dennis, Fuller, & Valacich, 2008) and novel technologies (Leonardi, 2013; Treem & Leonardi, 2012; Volkoff & Strong, 2013)[5]; this body of research has developed as two research steams: one considering fit of the technology with task needs and the other considering appropriation actions.

First, some scholars have investigated technology affordances as *functional features* in technologies like communication tools (Daft & Lengel, 1986; Webster & Trevino, 1995; Straub & Karahanna, 1998; Trevino, Webster, & Stein, 2000); healthcare information technology (Goh et al., 2011; Strong et al., 2014); and social media (Majchrzak et al., 2013; Nan & Lu, 2014; Treem & Leonardi, 2012). However, these studies have not considered the affordance-effectivity structure, users' perceptions of technology affordances, or the fit of perceived affordances with user needs and task needs in affordance actualization. These knowledge gaps call for not only an affordance-effectivity framework but also a variance perspective that emphasizes the role of input factors (users' affordance perceptions in combination with user needs and task needs) to jointly explain the outcomes of affordance actualization (Sabherwal & Robey, 1995; Van de Ven, 2007).

Second, other scholars have theorized technology affordance actualization as users' *appropriation* (Dennis & Garfield, 2003; DeSanctis & Poole, 1994; Markus & Silver, 2008) or *goal-directed actions* (e.g., Nan & Lu, 2014; Strong et al., 2014; Volkff & Strong, 2013). This viewpoint suggests a focus on deep structures embedded in actors and actions involved in

[5] The relational view underlying the affordance lens differs from (1) technological determinism, which emphasizes the power of a technology in shaping organizational structures and user behaviors, and (2) constructivism, institutionalism, and voluntarism, which focus on users' interaction with and/or subjective interpretation of a technology (DeSanctis & Poole, 1994; Hutchby, 2001; Leonardi & Barley, 2008). The affordance lens offers a theoretical stance that lies between technological determinism and constructivism or institutionalism, clarifying how individuals interact with and appropriate a technology in a particular use situation (Dennis et al., 2001; DeSanctis & Poole, 1994).

the process of affordance actualization. Uncovering deep structures as well as the different roles played by multiple actors and their respective appropriation actions corresponds to a process perspective (Pentland, 1999; Poole & DeSanctis, 2004; Sabherwal & Robey, 1993). However, a process perspective on user appropriation of affordances (DeSanctis & Poole, 1994; Poole & DeSanctis, 2004) has seldom been applied to understand traditional media use; rather, user appropriation has been captured in these studies through variance factors like familiarity, training, and social norms (Dennis et al., 2001; Dennis et al., 2008). As such, we leverage both variance and process perspectives to generate complementary insights on technology appropriation and use and the resulting impacts.

3.4 Decomposed Affordance-Effectivity Framework to Understand Physician-Patient Communication at Telecamps

We theorize physician-patient communication as the *actualized affordance* of the videoconferencing technology at telecamps and examine this actualized affordance using a decomposed affordance-effectivity framework and a combination of variance and process perspectives (Figure 2). With a variance perspective, we propose that patient satisfaction with teleconsultation (the actualized affordance) is related to the fit of patient-perceived media richness (technology affordance that enables physician-patient communication) through (1) disease diagnostic complexity (task needs arising from multiple-actor interactions) and (2) patient healthcare needs fulfillment (needs of patients as service consumers). In addition, using a process perspective, we focus on operators' different facilitative roles to explore multiple actors' affordance appropriation as compensatory user effectivity in affordance actualization. This combination of variance and process perspectives positions us to generate complementary insights into the affordance actualization of the videoconferencing technology in the telecamp context.

4 Evaluating Affordance Fit Using a Variance Perspective

Employing a variance perspective, we adopt a patient-centric view of affordance actualization at telecamps and develop two moderation hypotheses to capture the fit of the technology affordance with task needs and user needs. We used a survey methodology to collect the data to test the hypotheses.

4.1 Research Model and Hypotheses

We identify three antecedents of physician-patient communication: *patient-perceived media richness* (technology affordance that enables physician-patient communication), *disease diagnostic complexity* (task needs arising from multiple-actor interactions during teleconsultation), and *patient healthcare needs fulfillment* (user needs to consume the technology affordance) (Figure 3). Following insights from both IS and medical research, we focus on patient satisfaction with teleconsultation as the consequence of affordance actualization (Miller, 2001; Romanow, Rai, & Keil, 2018).

Patient satisfaction is especially critical in our telecamp context. If patients are not satisfied with the teleconsultation services, they could become demotivated from using the cost-effective healthcare services available to them in rural communities, which could lead to adverse consequences not only for their health but also for their overall well-being.

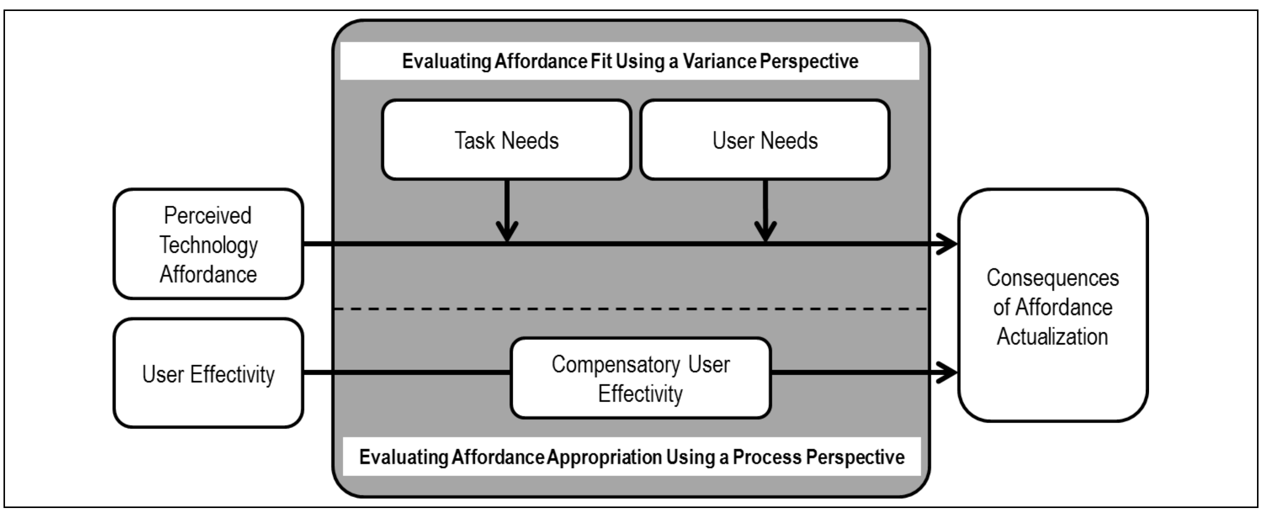


Figure 2. Decomposed Affordance-Effectivity Framework

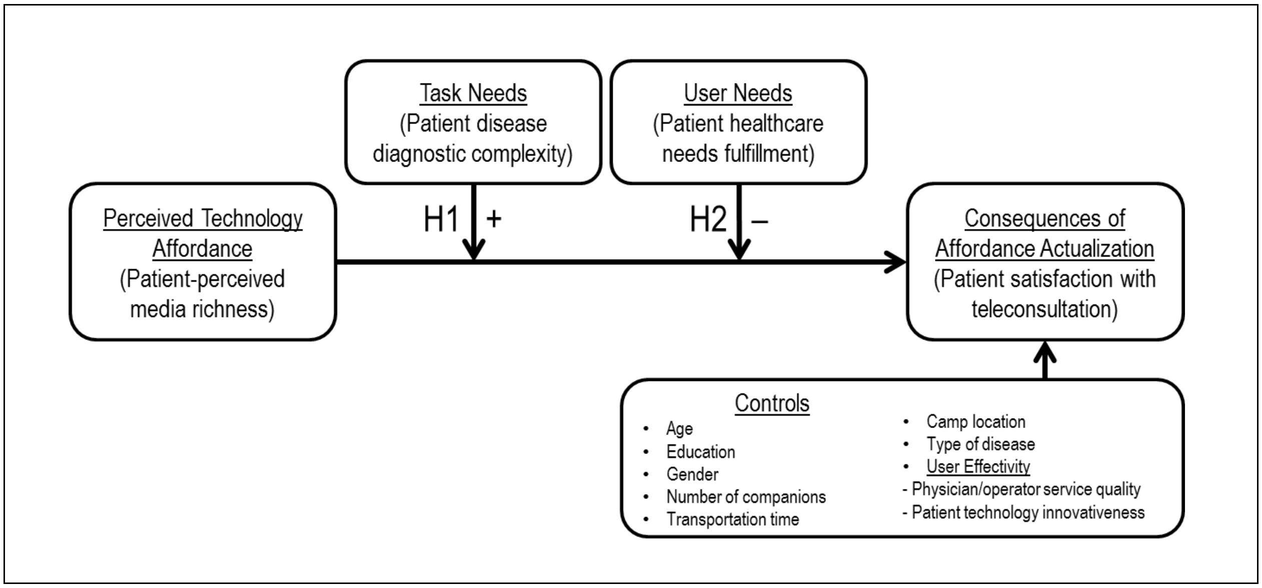


Figure 3. Research Model for Affordance Fit Using a Variance Perspective

We conceptualize media richness as the perceived affordance of the videoconferencing technology. *Patient-perceived media richness* refers to patients' perceptions of the videoconferencing medium's functionality for enabling communication between a patient and a physician during teleconsultation, which is an adaptation of the original definition from media richness theory (Daft & Lengel, 1986; Dennis & Kinney, 1998). Essentially, perceived media richness captures the utilitarian function of the videoconferencing technology in the telecamp context. When patients perceive that the medium richly conveys meaning in their communication with physicians during teleconsultation, telemedicine services are likely to be effectively delivered by remote physicians through the videoconferencing channel to local sites. Consequently, patients are likely to be satisfied with the telemedicine services they receive in the telecamp context. That is, patient satisfaction with teleconsultation is positively associated with patient-perceived media richness (Agha, Roter, et al., 2009; Bakken et al., 2006; Miller, 2001).

We suggest that the influence of perceived media richness on patient satisfaction is contingent on the needs of the task and the patient. First, disease diagnostic complexity most appropriately captures multiple-actor communication task needs (involving physicians, patients, and operators at telecamps) and likely positively moderates the influence of patient-perceived media richness on patient satisfaction with teleconsultation. Following the concept of diagnosticity (Herr, Kardes, & Kim, 1991; Jiang & Benbasat, 2005) and its application in physician-patient communication in teleconsultation (Serrano & Karahanna, 2016), we define *disease diagnostic complexity* as the degree of difficulty physicians face in understanding patients' symptoms and classifying conditions into specific medical categories. Diagnostic complexity varies across medical specialties (e.g., Unertl et al., 2009; Vos et al., 2014). For example, in neurology, physicians may ask patients to walk around and engage in other movements and also seek symptom information from patients or accompanying family members. In orthopedics, physicians perform diagnoses mainly based on symptom information from patients and from diagnostic procedures (e.g., x-rays, computerized tomography [CT] scans, magnetic resonance imaging [MRI]). For other conditions like the flu, certain allergies, and cataracts, physicians are often able to perform quick diagnoses based on unique and easily identifiable symptoms. We argue that high disease diagnostic complexity complicates communication between patients and physicians in teleconsultation. When disease diagnostic complexity is high (low), a communication task with high (low) complexity requires high (low) patient-perceived media richness to achieve fit between task and technology (Daft & Lengel, 1986; Goodhue, 1995). In other words, patient-perceived media richness and disease diagnostic complexity are *complementary* in their effect on patient satisfaction in that patients are more likely to be satisfied with teleconsultation for conditions that are hard to diagnose than for those that are easy to diagnose. Thus, we propose the following:

H1: Disease diagnostic complexity positively moderates the impact of patient-perceived media richness on patient satisfaction with teleconsultation such that the higher the disease diagnostic complexity, the stronger the impact of patient-perceived media richness on patient satisfaction.

We suggest that the relationship between patient-perceived media richness and patient satisfaction is also contingent on user needs to consume the affordance of the videoconferencing technology—that is, on patient healthcare needs fulfillment. Drawing on needs fulfillment theory (Au, Ngai, & Cheng, 2008; Oliver 1995), we define *patient healthcare needs fulfillment* as the extent to which patients feel their needs for healthcare services are fulfilled. As such, patient healthcare needs fulfillment captures patients' perceived ability to afford healthcare services in terms of quality, cost, and timeliness (Ganapathy et al., 2016; Hong 2016; Kummervold et al. 2012; Muller et al. 2016) and is not to be misconstrued as patients' appraisal of the extent to which a teleconsultation session received in a telecamp fulfilled their healthcare needs. Low (high) patient healthcare needs fulfillment signifies patients' high (low) potential to consume the affordance of the videoconferencing technology during physician-patient communication processes.[6] Patient healthcare needs fulfillment varies across individuals in general and likely also varies across underprivileged patients even though their access to healthcare services is constrained—they might be more/less healthy and more/less concerned about their health conditions, and even with constrained access to healthcare, they might still have more/less access to healthcare facilities and services. A low level of patient healthcare needs fulfillment means that patients have limited access to healthcare services and that teleconsultation could be one of the only channels for them to receive healthcare services. Therefore, when patient healthcare needs fulfillment is low (high), patients are likely to value the videoconferencing medium to a greater (lesser) extent when appraising the effectiveness of telecamps (i.e., their satisfaction with the teleconsultation they received at telecamps). As such, patient healthcare needs fulfillment and patient-perceived media richness are *substitutive* in their effect on patient satisfaction with teleconsultation. Based on the above argument, we propose the following:

H2: Patient healthcare needs fulfillment negatively moderates the impact of patient-perceived media richness on patient satisfaction with teleconsultation such that the lower the level of patient healthcare needs fulfillment, the stronger the impact of patient-perceived media richness on patient satisfaction.

4.2 Survey

Sites and sample: We surveyed patients at two free telecamps held in February 2012 in the villages of Srirangam and Bodinayak in the state of Tamil Nadu in South India. Both camps were jointly held by the local Indian government, NGOs, and the Apollo Telemedicine Networking Foundation (ATNF) (see Appendix A.) Our survey instrument included (1) measures for the constructs in the research model, including patient-perceived media richness, patient healthcare needs fulfillment, and patient satisfaction with teleconsultation; (2) the disease conditions of the patients at the camps as determined by the evaluating physicians and recorded in the patient roster; and (3) several demographic variables (age, education, gender, individual/household income, distance traveled/mode of travel to the telecamp, number of companions who accompanied the patients to the camp, camp location, and use/non-use of a list of mobile phone services). Apollo Hospitals hired multilingual professionals to help with questionnaire translation and back-translation between English and Tamil (Brislin, Lonner, & Thorndike, 1973). Camp volunteers from Apollo Hospitals underwent a two-day training on the protocol for verbal data collection from patients. The protocol included how to explain the objectives of the study (i.e., understanding the effectiveness of teleconsultation at telecamps) and the key terms (e.g., videoconferencing technology, teleconsultation, and telecamp) to patients and how to verbally administer the survey to patients and record their answers. Using the protocol, the camp volunteers verbally administered the survey to a sample of randomly selected patients after their teleconsultation sessions and recorded the patients' responses. We obtained 216 responses in total (see Appendix B1 for the survey sample profile).

Measures: We adapted measures for patient satisfaction with teleconsultation (three items) (Sykes, Venkatesh, & Rai, 2011) and patient-perceived media richness (three items) (Dennis & Kinney, 1998) and developed a three-item measure for patient healthcare needs fulfillment covering cost affordability, timeliness (Ganapathy et al., 2016; Muller et al., 2016), and quality (Hong, 2016; Kummervold et al., 2012) (see Appendix B2). We consider patient healthcare needs fulfillment to be a meaningful contingency construct in the telecamp context although one could reasonably expect that, in comparison to others, underprivileged patients lack access to healthcare resources. For example, underprivileged patients may vary in terms of health conditions, awareness of their health conditions, transportation resources, time available to visit clinics, and monetary resources, thereby demonstrating reasonable variance in the three-item measure. We used a five-point Likert scale to capture responses to the measures (1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*). We worked with highly experienced

[6] In our empirical analysis, we also controlled for physicians' and operators' effectivity (i.e., service quality). See Figure 3 and Footnote 8 below.

physicians to classify diseases into low and high levels of disease diagnostic complexity based on the diagnostic characteristics of the diseases (see Appendix B3). We controlled for patients' age, gender, education levels, and transportation time to the camp. We also controlled for number of companions who accompanied the patient to the camp, camp location, and patient technology innovativeness[7].

Analysis and results: Table 2 shows the correlations as well as the composite reliability, Cronbach's alpha, and average variance extracted (AVE) for the three multi-item constructs. The values for Cronbach's alpha and composite reliability were all higher than the recommended 0.707 (Nunnally & Bernstein, 1994), and the values for AVE were all above 0.50 (Fornell & Larcker, 1981), supporting internal consistency and convergent validity. Discriminant validity was supported because the AVE value for each construct was higher than its squared correlations with other constructs (Chin, 1998).

We used ordinary least squares (OLS) regression to test our hypotheses. We mean-centered patient-perceived media richness and patient healthcare needs fulfillment to mitigate multicollinearity between the interaction terms and their components. Tables 3 and 4 display the OLS results.[8,9] Specifically, the coefficient for the interaction between patient-perceived media richness and disease diagnostic complexity (PMR * DC) on patient satisfaction was 0.13 ($p = 0.036$), which means that the influence of patient-perceived media richness on patient satisfaction was stronger when disease diagnostic complexity was high (vs. low), thus supporting H1. The coefficient for the interaction between patient-perceived media richness and patient healthcare needs fulfillment (PMR * HNF) on patient satisfaction was -0.15 ($p = 0.001$), which means that the influence of patient-perceived media richness on patient satisfaction was weaker when patient healthcare needs fulfillment was high (vs. low), thus supporting H2. With respect to the main effects of the independent variables and moderators on patient satisfaction, we observed positive significant effects for patient healthcare needs fulfillment (0.46, $p = 0.000$) and patient-perceived media richness (0.58, $p = 0.000$) and a nonsignificant effect for disease diagnostic complexity.[10] We performed Heckman's two-stage test to check the robustness of our findings to selection bias. The moderation effects remained qualitatively unchanged after controlling for the inverse Mill's ratio (Kwon & Johnson, 2014; Thirumalai & Shinha, 2013).[11]

We limited our focus in the variance study to the impact of patient-perceived media richness, contingent on disease diagnostic complexity and patient healthcare needs fulfillment, on patient satisfaction. Next, we explored the appropriation actions of multiple actors (including patients, physicians, and on-site operators) using a process perspective with a particular emphasis on operators' multiple roles, which provided a complementary view of the findings from the variance perspective.

[7] We employed use of mobile phone services as an appropriate way to capture patient technology innovativeness (i.e., Saidin Index of echnology) (Spetz & Baker, 1999). Using a binary response format, we asked patients about their use or non-use of a list of mobile phone services: phone calls, text messages, emails, internet access, shopping, banking, entertainment, work-related information, and health-related information. For each mobile phone service, we assigned a weight a_k, where $a_k = 1 - \left(\frac{1}{N}\right)\sum_{i=1}^{N_i} \tau_{i,k}$, N is the total number of patients in the sample, and $\tau_{i,k}$ takes the value 1 if patient *i* uses mobile service *k* and 0 otherwise. We then used these weights to compute the Saidin Index s_i for patient i: $s_i = \sum_{k=1}^{k} a_k \tau_{i,k}$.

[8] There were eight physicians and five operators in the two telecamps where we collected the survey data. We included dummy variables for "physicians" and "operators" in our model specifications to account for physician and operator fixed effects and evaluated the robustness of the results. Our results were stable with this inclusion.

[9] We assessed common method bias using Harman's single-factor test (Podsakoff & Organ, 1986) and the marker variable test (Lindell & Whitney, 2001). The results of both tests indicate that common method bias was not a serious validity threat.

[10] We observed that patients with higher healthcare needs fulfillment responded more favorably to the teleconsultation services at telecamps. This observation suggests that those who felt that their healthcare needs had been better fulfilled overall were more likely to positively appraise teleconsultation services.

[11] We applied the Heckman's test as follows: In the first-stage probit model, we dichotomized perceived media richness, coding the cases with perceived media richness above (below) the sample mean as 1 (0). We specified this dichotomized variable as the outcome and used the following as predictors: teleconsultation satisfaction plus all the control variables listed in the research model capturing demographics (age, education, gender), individual variation in disposition toward new mobile services (patient technology innovativeness), social support (number of companions who accompanied the patient to the camp), access costs to the camps (transportation time), and geography (location of the camp). Based on this first-stage probit model specification, we calculated the inverse Mill's ratio (IMR = $\varphi(\chi_i\gamma)/\Phi(\chi_i\gamma)$, where φ stands for the probability density function, Φ is the cumulative density function, χ_i is the vector of independent variables, and γ is the coefficients from the first-stage probit model (Heckman 1979; Shaver 1998). We then included the inverse Mill's ratio in estimating the moderation model in the second-stage OLS regression.

Table 2. Descriptive Statistics

		Age	Edu	Gen	Comp	TransT	Camp	PIT	PMR	DC	HNF
Control variables	**Edu**	- 0.07									
	Gen	0.09	- 0.06								
	Comp	- 0.21**	0.08	0.05							
	TansT	- 0.03	- 0.14*	0.07	0.08						
	Camp	- 0.03	- 0.21**	- 0.05	0.05	0.23**					
	PIT	- 0.09	0.10	- 0.05	0.15*	0.15*	0.26**				
	PMR	- 0.28**	0.12	- 0.03	0.09	0.02	0.39**	0.17*			
	DC	0.08	- 0.15*	0.08	0.07	0.03	0.24**	0.09	- 0.10		
	HNF	- 0.11	0.36**	- 0.01	0.26**	- 0.18**	- 0.54**	- 0.10	0.13	- 0.23**	
	Sat	- 0.24**	0.18**	- 0.04	0.23**	- 0.09	0.28**	0.23**	0.77**	- 0.04	0.39**

	Mean	Standard deviation	Cronbach's alpha	Composite reliability	AVE (square root of AVE)
PMR	3.54	0.95	0.90	0.94	0.84 (0.91)
HNF	3.10	1.00	0.91	0.96	0.92 (0.96)
Sat	3.39	0.84	0.89	0.93	0.82 (0.90)

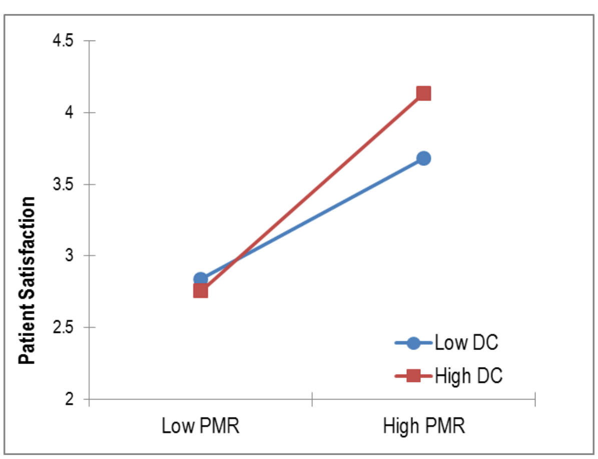
Notes: Edu = education, Gen = gender, Comp = number of companions, TransT = transportation time, Camp = camp location, PTI = patient technology innovativeness, PMR = patient-perceived media richness, DC = disease diagnostic complexity, HNF = patient healthcare needs fulfillment, Sat = patient satisfaction with teleconsultation, AVE = average variance extracted. ***p* < 0.01, **p* < 0.05, two-tailed test.

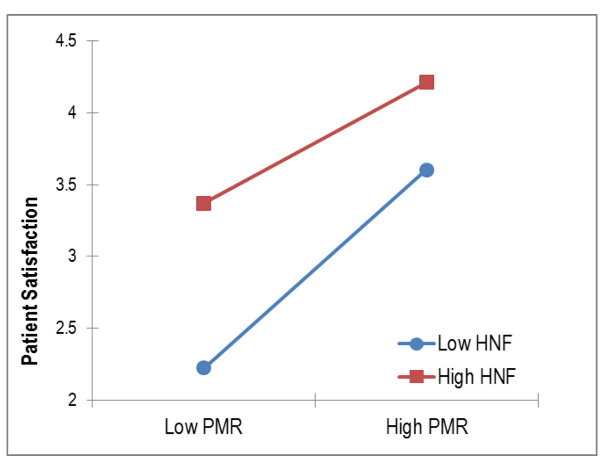
Table 3. OLS Results (DV = Patient Satisfaction with Teleconsultation)

	Control		Main		Interaction	
Age	- 0.18**	(0.002)	- 0.01	(0.418)	- 0.02	(0.325)
Education	0.19**	(0.002)	- 0.02	(0.341)	0.00	(0.491)
Gender	0.01	(0.411)	0.01	(0.415)	- 0.01	(0.346)
Number of companions	0.15**	(0.008)	0.03	(0.257)	0.02	(0.334)
Transportation time	- 0.17**	(0.005)	- 0.10**	(0.003)	- 0.10**	(0.005)
Camp location[a]	0.32**	(0.000)	0.28**	(0.000)	0.23**	(0.000)
Patient technology innovativeness	0.11*	(0.045)	0.11**	(0.002)	0.09**	(0.008)
Patient-perceived media richness (PMR)			0.58**	(0.000)	0.39**	(0.000)
Disease diagnostic complexity (DC)[b]			0.05	(0.114)	0.04	(0.116)
Patient healthcare needs fulfillment (HNF)			0.46**	(0.000)	0.44**	(0.000)
PMR * DC (H1)					0.13*	(0.036)
PMR * HNF (H2)					- 0.15**	(0.001)
R^2	24.1%		74.4%		76.1%	

Notes: [a] Camp location: 0 = Srirangam; 1 = Bodinayak. [b] Disease diagnostic complexity: 1 = high; 0 = low. ** *p* < 0.01, * *p* < 0.05, one-tailed test as directional effects are hypothesized. Standardized coefficients shown; *p*-values in parentheses. The variance inflation factor (VIF) values of the moderation models ranged from 1.027 to 6.190, indicating no harmful multicollinearity. The condition number equaled 8.87, which is below the rule of thumb of 30. The change in R^2 between the second and third models was 1.7%, F-square = 0.071 (small to medium effect size) (Mathieson, Peacock, & Chin, 2001).

Table 4. Interaction Plots





Notes: PMR = patient-perceived media richness, DC = disease diagnostic complexity, HNF = patient healthcare needs fulfillment.

5 Evaluating Affordance Appropriation Using a Process Perspective

We adopted a process perspective to investigate how operators' facilitative roles (content, sequence, and duration) assisted multiple actors' actions to appropriate the videoconferencing technology at telecamps. We followed protocols for process analysis (Bakeman & Gottman, 1997; Barley, 1990; Van de Ven, 2007) to code 46 teleconsultation video archives from two free telecamps (the same camps where we collected the survey data) and used nonparametric analysis to analyze the coded video data.

5.1 Process Analysis Procedures

Process analysis can be used to reveal deep structures embedded in contexts, moving "from description to explanation" (Pentland, 1999, p. 712). Whereas process analysis has traditionally been applied to generalize event sequence patterns across a list of cases (Bakeman & Gottman, 1997; Sabherwal & Robey, 1995; Van de Ven, 2007), we adopted a more pluralistic approach and examined deep structures embedded in actors' roles (operators in particular) in terms of *content, sequence, and duration* (Pentland, 1999). We conceptualized operators' multiple facilitative roles as *compensatory user effectivity* in physician-patient communication at telecamps.

Figure 4 summarizes our four-step process analysis procedure. Step 1 involved two expert coders independently developing narrative scripts for the 46 video sessions in third-person voice (Bakeman & Gottman, 1997; Van de Ven, 2007) using the following rules: (1) identify actor(s) and action(s) in each sentence; (2) do not combine actions; and (3) avoid attempting to capture thoughts, emotions, and other unobservable behaviors (Sabherwal & Robey, 1993, 1995). Based on their respective narrative scripts, the coders independently developed a list of actors who were named based on their designated roles in the patient-physician communication process. There was complete agreement between the two coders on the *actor list*, which included patient at the local site, companion who accompanied the patient to the local site, [12] and operator at the local site with technician responsibility, as well as physician and administrative secretary[13] at the remote site. There was also very high agreement between the coders on the action list, with one coder identifying an extra action.[14] Step 2 involved a third expert coder developing a *communication event list*, which is a classification of actions according to four communication goals that the actions seek to accomplish; [15] the actions were mapped to their communication goals, which included physical examination, general diagnostic information, clinical test results, and medication history. The first two coders then assessed this communication event list and unanimously agreed with it. Step 3 involved the three coders working together to develop two video-archive coding protocols: (1) physician-patient communication events (based on the communication event list developed in Step 2) and (2) operators' facilitative roles (based on the designated roles of the different actors identified in Step 1 that the operator enacted in a teleconsultation session). We applied these coding protocols to the video archives to capture the deep structures embedded in operators' multiple roles that were enacted along with the key communication events during physician-patient communication processes in a teleconsultation session. Finally, Step 4 focused on examining the operators' facilitative roles during a teleconsultation session through qualitative observations of role sequence as well as nonparametric tests relating to role duration.

The teleconsultation video archives mainly covered three medical specialties—orthopedics ($n = 20$), dermatology ($n = 10$), and neurology ($n = 12$)—all representing high disease diagnostic complexity in relation to other diseases treated at the telecamps (see Appendices B3 and C1 for details). As confirmed by physicians with extensive knowledge across specialties as well as telemedicine experience, the three medical specialties differ in their relative requirements for videoconferencing technology, clinical tests, and medication history as follows: (1) technology (media) is most critical for dermatology, followed by neurology and then orthopedics; (2) clinical tests are most critical for neurology and orthopedics and much less critical for dermatology; and (3) medication history is most crucial for dermatology and much less critical for neurology and orthopedics (see Appendix C2). Accordingly, the communication events and the enactment of roles in the teleconsultation can reasonably be expected to differ for these medical specialties.

[12] On very few occasions, companions helped patients communicate with physicians. There were five video sessions in our archives in which a companion was present, including one dermatology case, three neurology cases, and one other case (see Appendix C1).

[13] Secretaries were present on the screen with the physicians but did not participate in the physician-patient communication processes.

[14] One coder identified 12 actions while the other identified 11. In the process of constructing the action lists, we reconciled expected terminology differences between coders in naming an action; for example, the action of asking a patient to perform an activity may have been labeled "ask the patient" by one coder and "request the patient" by the other coder.

[15] Aggregating actions that share the same goal into a single event category is consistent with the process perspective that interprets affordance as goal-oriented actions in both ecological psychology (Karda & Shaw, 2000) and the IS literature (Markus & Silver, 2008, p. 622). Our approach of abstracting observed actions and actors to higher-level event categories is informed by past work on process studies (e.g., Sabherwal & Robey, 1993).

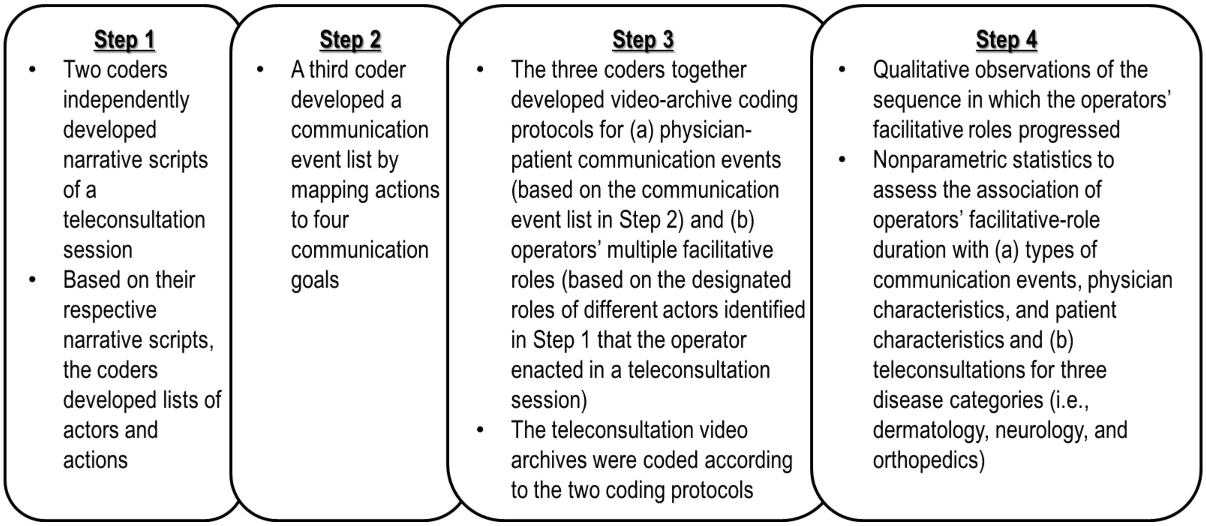


Figure 4. Analysis Procedures with the Process Perspective

Table 5. Descriptive Information of Coded Video Archives

			Occurrence frequency		Frequency percentage (%)	Duration (seconds) Mean	Duration (seconds) SD
Protocol 1: Physician-patient communication events	Verbal communication	Event 1: Diagnostic information	None	0	0	104.89	52.48
			Yes	46	100.00		
		Event 2: Clinical test results	None	43	93.48	5.67	22.13
			Yes	3	6.52		
		Event 3: Medication history	None	43	93.48	7.41	34.45
			Yes	3	6.52		
		Sum of verbal communication events (1, 2, 3):	None	0	0	117.98	69.82
			Yes	46	100.00		
	Nonverbal communication	Event 4: Physical examination	None	22	47.83	18.39	28.07
			Yes	24	52.17		
Protocol 2: Operators' facilitative roles	Technical facilitation	Role 1: Technician	None	17	36.96	11.57	15.03
			Yes	29	63.04		
	Process facilitation	Role 2: Physician	None	31	67.39	15.07	30.89
			Yes	15	32.61		
		Role 3: Patient	None	18	39.13	48.24	66.36
			Yes	28	60.87		

5.2 Two Coding Protocols: Physician-Patient Communication Events and Operators' Facilitative Roles

As described above, we developed coding protocols for physician-patient communication events and operators' facilitative roles and applied them to code the teleconsultation video archives. Table 5 presents descriptive information of the coded video archives based on the coding protocols.

5.2.1 Protocol 1: Physician-Patient Communication Events

Protocol 1 focused on coding the communication events among key actors (i.e., physicians, patients, and operators) in the patient-physician communication process. We classified communication events into two mutually exclusive and exhaustive dimension categories (Bakeman & Gottman, 1997): (1) *verbal communication*, which is broken down into three subtypes, including general diagnostic information/symptoms, clinical test results, and medication history; and (2) *nonverbal communication*, which entails the physical examination through videoconferencing (e.g., physicians watch neurology patients' movement through videoconferencing) or dermascope (e.g., physicians use a dermascope to examine patients' skin conditions). In aggregate, both verbal and nonverbal communication events were salient across teleconsultation sessions.

5.2.2 Protocol 2: Operators' Facilitative Roles (Role Content)

Protocol 2 focused on coding the operators' facilitative roles in patient-physician communication process. Operators at the telecamps provide chauffeur-driven facilitation (Dickson, Partridge, & Robinson, 1993); they activate a particular role only upon request or when a need arises and never directly influence the diagnostic or decision-making processes (Dennis et al., 2001; Griffith, Fuller, & Northcraft, 1998). We identified three mutually exclusive operator roles that facilitate physician-patient communication: (1) *technician* (e.g., adjusts the dermascope, lights, sound volume, and videoconferencing connection via a computer), (2) *physician* (e.g., explains a physician's medical jargon-laden instructions and questions to a patient in lay terms, possibly involving translation of English into Tamil), and (3) *patient* (e.g., helps patients explain symptoms and respond to physician questions, possibly involving translation of Tamil into English). This categorization is consistent with the technical versus process facilitation classification originating from adaptive structuration theory (Griffith et al., 1998; Niederman, Beise, & Beranek, 1996); the role of technician captures technical facilitation and the roles of physician and patient capture process facilitation. Operators' technical and process facilitative roles were both prominent in the teleconsultation sessions.

5.3 Operators' Facilitative Roles: Qualitative Observations and Nonparametric Statistics

5.3.1 Qualitative Observations of Operators' Facilitative-Role Sequence

We uncovered two sequences that differ when each of the operators' facilitative roles manifested in the teleconsultation processes. The first was the *technician role alongside a nonverbal communication event*: for example, an operator adjusted the dermascope, lights, sound volume, or videoconferencing connection either before, during, or after a physical examination. The second was the *patient/physician role during or after a verbal communication event*: for example, an operator conveyed physicians' instructions to the patient or patients' answers to the physician.

5.3.2 Nonparametric Statistics Pertaining to Operators' Facilitative-Role Duration

We used nonparametric tests (Conover, 1999) to compare the correlation between the duration of each operator role with physician-patient communication events and physician and patient characteristics. Regarding the association between operator roles and the length of communication events, we found that (1) operators' technician role significantly correlated with the duration of nonverbal communication events and that (2) operators' patient role significantly correlated with the duration of verbal communication events (Table 6a). Looking at the association between physician experience and roles, we found that (1) physicians' years of experience in their specialty positively correlated with operators' technician role, suggesting that more experienced physicians, who also tended to be older, required more technical assistance using the virtual channel, and that (2) greater physician experience with telecamps negatively correlated with operators' technician role, suggesting that these physicians were more adept at using the virtual channel (Table 6b). Turning to the association of patient demographics with the operators' roles (Table 6c), we found that patient age negatively correlated with operators' technician role, suggesting that children and adolescents (younger patients in our video archives) required more technical assistance from operators during physical examinations.

Table 6a. Correlations of the Duration of Operators' Facilitative Roles with Duration of Communication Events

		Duration of verbal communication				Duration of nonverbal communication			
		Kendall's tau		Spearman's rho		Kendall's tau		Spearman's rho	
Technical facilitation	Role as a technician	0.161	(0.067)	0.219	(0.072)	0.340**	(0.002)	0.441**	(0.001)
Process facilitation	Role as a physician	0.030	(0.397)	0.041	(0.393)	0.169	(0.084)	0.195	(0.097)
	Role as a patient	0.204*	(0.029)	0.245*	(0.049)	0.101	(0.189)	0.139	(0.178)

Table 6b. Correlations of the Duration of Operators' Facilitative Roles with Physician Characteristics

		Physician years of experience in specialty				Physician telecamp experience			
		Kendall's tau		Spearman's rho		Kendall's tau		Spearman's rho	
Technical facilitation	Role as a technician	0.338**	(0.003)	0.410**	(0.003)	- 0.238*	(0.023)	- 0.280*	(0.030)
Process facilitation	Role as a physician	0.172	(0.089)	0.200	(0.094)	- 0.029	(0.410)	- 0.024	(0.437)
	Role as a patient	0.052	(0.334)	0.065	(0.335)	0.023	(0.422)	0.028	(0.427)

Table 6c. Correlations of the Duration of Operators' Facilitative Roles with Patient Characteristics

		Patient age				Patient gender			
		Kendall's tau		Spearman's rho		Kendall's tau		Spearman's rho	
Technical facilitation	Role as a technician	- 0.228*	(0.018)	- 0.283*	(0.029)	- 0.063	(0.314)	- 0.072	(0.317)
Process facilitation	Role as a physician	0.115	(0.161)	0.146	(0.166)	- 0.160	(0.123)	- 0.173	(0.125)
	Role as a patient	- 0.015	(0.446)	- 0.036	(0.407)	- 0.192	(0.069)	- 0.221	(0.070)

Notes: p-values are reported within parentheses. $^{**}p < 0.01$, $^{*}p < 0.05$, one-tailed test.

Table 7. Operators' Facilitative Roles and Communication Events Across Orthopedics, Dermatology, and Neurology Teleconsultation

		Occurrence frequency			Mean duration			Mann-Whitney U		
		Ortho (1)	Derm (2)	Neuro (3)	Ortho (1)	Derm (2)	Neuro (3)	1 vs. 2	1 vs. 3	2 vs. 3
Comm. events	Verbal communication	20/100%	10/100%	12/100%	76.40"	113.70"	174.50"	49* (0.012)	25** (0.000)	26.5* (0.013)
	Nonverbal communication	5/25%	6/60%	11/92%	6.50"	12.20"	43.17"	64* (0.048)	24.5** (0.000)	21.5** (0.005)
Operators' facilitative roles	Role as a technician	10/50%	8/80%	10/83%	5.40"	24.40"	14.00"	39.5** (0.003)	53.5** (0.004)	47 (n.s.) (0.209)
	Role as a physician	6/30%	1/10%	6/50%	6.9"	6.2"	28.83"	82 (n.s.) (0.224)	83(n.s.) (0.079)	36 (n.s.) (0.062)
	Role as a patient	13/65%	3/30%	9/75%	35.5"	17.8"	80.83"	65.5 (n.s.) (0.066)	98.5(n.s.) (0.204)	31.5* (0.030)

Notes: p-values are reported within parentheses. $^{**}p < 0.01$, $^{*}p < 0.05$, one-tailed test. Orthopedics, dermatology, and neurology abbreviated as ortho, derm, and neuro, respectively; Communication events abbreviated as Comm. events

Next, we examined differences in the duration of the different operator roles and communication events across orthopedics, dermatology, and neurology. Table 7 presents the occurrence frequencies of verbal and nonverbal communication events and each of the three operator roles as well as their mean duration across the three medical categories. Table 7 also shows the Mann-Whitney U test results for pairwise mean-duration comparisons for the communication events between the three medical specialties. The Mann-Whitney U test results suggest that (1) both verbal and nonverbal communication event duration in neurology, dermatology, and orthopedics followed a descending order; (2) the duration of operators' technician role was longer for dermatology and neurology than for orthopedics; (3) the duration of operators' patient role was longer for neurology than for dermatology; and (4) there were no detectable differences in the duration of operators' physician role across neurology, dermatology, and orthopedics.

Overall, the qualitative observations and the nonparametric statistics yielded consistent yet complementary findings, which we illustrate in Figure 5. First, in our qualitative observations, the different operator roles accompanied different communication events and likely facilitated information exchange between physicians and patients through videoconferencing at the telecamps. Specifically, operators' physician and patient roles closely related to verbal communication events, while their technician role closely related to nonverbal communication events. In the nonparametric statistics, only the duration of operators' physician role was not related to communication events, physician or patient characteristics, or medical specialties. This result might imply that the demand for operators' physician role during teleconsultation sessions was relatively stable regardless of patients' health conditions, communication capabilities, or demographic background or physicians' level of expertise in their specialty or experience with telemedicine.

Second, while neurology, dermatology, and orthopedics were all high in disease diagnostic complexity (see Appendix B1), the processes to appropriate videoconferencing for telemedicine still varied across them. Although both verbal and nonverbal communication event duration in neurology, dermatology, and orthopedics displayed a descending order, these medical categories posed different requirements on operators' facilitative roles during physician-patient communication processes at the telecamps. Our findings suggest that neurology teleconsultation required more operator involvement in both the technician and patient roles, while dermatology teleconsultation required operator involvement only in the technician role. Compared with traditional face-to-face consultation, diagnosing neurological problems through the videoconferencing channel relied heavily on technology bandwidth, as higher bandwidth was required to observe nuanced disturbances in patient movement.

Similarly, diagnosing dermatology problems required high technology bandwidth to observe patient skin conditions, especially when a dermascope was used at the patient site. In contrast, diagnosing orthopedic problems usually relied on radiology reports based on imaging (e.g., x-rays, CT scans, MRI) in both face-to-face and teleconsultation settings.

Table 8 summarizes the operators' facilitative roles in terms of content, sequence, and duration. In particular, the multiple roles played by operators served as compensatory user effectivity, which *ensured* the technology affordance was effectively actualized (e.g., unstable electricity and networks) and *compensated* for the limited effectivity of either patients (e.g., limited healthcare awareness and communication skills) or physicians (e.g., ability to conduct a physical examination in person). In other words, operators' multiple chauffeur-driven roles (Dickson et al., 1993) served as features that enhanced patients' or physicians' capabilities so they could better realize the perceived affordance of the videoconferencing technology in the teleconsultation sessions.

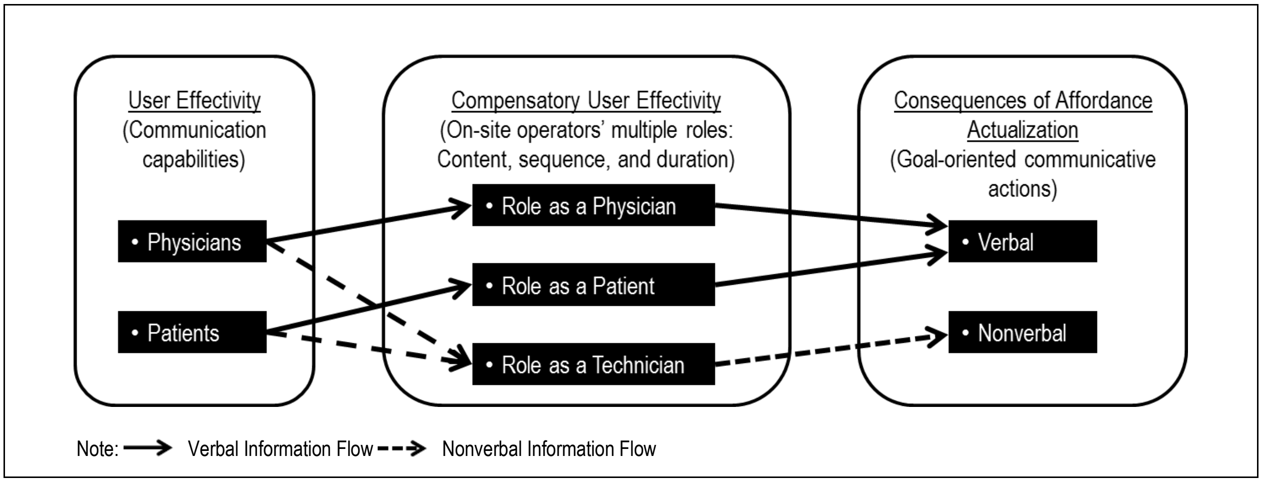


Figure 5. Appropriation Actions and Compensatory User Effectivity

Table 8. Operators' Facilitative Roles: Content, Sequence, and Duration

	Role as a physician	Role as a patient	Role as a technician
Content	• Explained to a patient in lay terms the physician's instructions and questions about symptoms or diagnoses	• Helped patients explain symptoms and respond to physicians' questions	• Adjusted the dermascope, lights, sound volume, and videoconferencing connection via a computer
Sequence	• Along with a verbal communication event, either during or after verbal communication—for example, after a physician asked questions or requested more disease-related information	• Along with a verbal communication event, either during or after verbal communication—for example, after a patient responded to a physician but needed further clarification	• Along with a nonverbal communication event, either before, during, or after physical examination
Duration (not depicted in Figure 5)	• Similar across neurology, dermatology, and orthopedics • No correlation with either verbal or nonverbal communication duration	• Positively correlated with verbal communication duration • Longer for neurology than for dermatology	• Positively correlated with nonverbal communication duration • Longer for young patients (children or adolescents) • Longer for physicians more experienced in their specialty or physicians less experienced with telecamps • Longer for dermatology/ neurology than for orthopedics

Table 9. Summary of Study

<table>
<tr><th></th><th>Variance perspective</th><th>Process perspective</th></tr>
<tr><td>Research question</td><td>• What impact does the fit of patient-perceived media richness (i.e., technology affordance for physician-patient communication) with two contingencies—(1) disease diagnostic complexity (task needs) and (2) patient healthcare needs fulfillment (user needs)—have on patient satisfaction (actualization affordance of the technology)?</td><td>• How do multiple actors appropriate the videoconferencing technology through goal-oriented actions so as to actualize its affordance at telecamps?</td></tr>
<tr><td>Data and methods</td><td>• Survey for primary data collection from patients (OLS regression)</td><td>• Video archives of teleconsultation sessions (process analysis of videos, nonparametric statistics)</td></tr>
<tr><td>Findings</td><td>• Patient-perceived media richness (technology affordance that enables physician-patient communication) and disease diagnostic complexity (task needs) displayed a complementary relationship in affecting patient satisfaction with teleconsultation services at telecamps (consequence of affordance actualization)
• Patient-perceived media richness (technology affordance that enables physician-patient communication) and patient healthcare needs fulfillment (service consumers' needs) displayed a substitutive relationship in affecting patient satisfaction with teleconsultation services (consequence of affordance actualization)</td><td>• Physician-patient communication events were segmented into two main categories: verbal and nonverbal (Video Coding Protocol 1)
• Operators played three facilitative roles—technician, physician, and patient—in teleconsultation sessions (Video Coding Protocol 2)
• Operators' different facilitative roles took place along with particular communication events, serving as compensatory user effectivity for physicians and patients as well as affordance actualization of the videoconferencing at telecamps
• Operators' enactment of different facilitative roles varied across medical categories</td></tr>
<tr><td>Implications for research</td><td colspan="2">• Elaborated the affordance lens through a decomposed affordance-effectivity framework to understand how to effectively use videoconferencing technology for teleconsultation at telecamps, yielding the following insights:
◦ The influence of perceived technology affordance on affordance actualization is contingent on the needs of multiple actors and tasks at telecamps
◦ Compensatory user effectivity facilitates multiple actors' appropriation of videoconferencing to cost-effectively provide telemedicine to villages in less developed countries
◦ The healthcare information technology "design-reality gap" between technology and current practices with information, processes, personnel skills, and structures can effectively be bridged through situational improvisation by on-site operators who enact different roles during teleconsultation sessions
• Generated insights regarding the three levels of technology impact on the health divide in rural areas of less developed countries
• Demonstrated how complementary insights about complex technology use phenomena can be generated by combining variance and process perspectives as well as qualitative and quantitative methods</td></tr>
<tr><td>Implications for practice</td><td colspan="2">• Policy makers: generated insights on how frugal technologies can be deployed for cost-effective teleconsultation at telecamps located in villages in less developed countries
• Hospital management: provided guidance for developing training programs for operators to compensate for frugal technologies, constrained infrastructure, and communication barriers</td></tr>
</table>

6 Discussion

Table 9 summarizes the research questions we investigated, the variance and process perspectives that we employed, the findings, and the implications for practice and future research.

6.1 Implications for Research

First, our study elaborated the affordance lens through a decomposed affordance-effectivity framework to understand *how to effectively use videoconferencing technology for teleconsultation at telecamps*. In particular, we identified multiple actors—service providers (physicians), service consumers (patients), and facilitators (on-site operators)—as users of the videoconferencing technology at telecamps (Figure 1). In our study, operators' use of videoconferencing was largely driven by triggers from physicians and patients during teleconsultation at the telecamps (e.g., when physicians asked operators to perform on-site physical examinations of patients or when patients needed help translating their conditions from their local languages into English or even into medical jargon). In other words, when health consultation services migrate into the virtual channel (Overby, 2008; Overby et al., 2010), physicians and patients cannot just perform the same activities they would in face-to-face settings and must rely extensively on operators as a key resource to engage in situational improvisation to effectively execute the virtualized process. In addition, the influence of perceived technology affordance on affordance actualization is contingent on the needs of patients as service consumers and the needs of communication tasks at telecamps.

We also surfaced the role of compensatory user effectivity in facilitating multiple actors' appropriation of videoconferencing to deliver cost-effective telemedicine to villages in less developed countries. Our process analysis took a pluralistic approach and identified the deep structures (i.e., operators' facilitative roles in terms of content, sequence, and duration) embedded in multiple actors' appropriation actions at telecamps. The three operator roles functioned as compensatory user effectivity to facilitate affordance actualization of the videoconferencing technology in delivering cost-effective telemedicine services at the telecamps. Specifically, operators' physician and patient roles helped overcome verbal communication hurdles between physicians and patients, and operators' technician role assisted in nonverbal communication. The duration of the different roles varied across medical categories (dermatology, neurology, and orthopedics) that were high in disease diagnostic complexity but required different types of support from operators given the frugal technology, patient population with low literacy, and unstable power and bandwidth connections with urban physicians. Overall, compensatory user effectivity countered the various technical and infrastructure limitations in rural India and enabled effective physician-patient communication at the telecamps.

Elaborating on the effective use of frugal videoconferencing technology for cost-effective telemedicine delivery through a third-party technology user, our study contributes to the understanding not only of compensatory user capabilities in teleconsultation (Serrano & Karahanna, 2016) but also of effective IS use in general (Burton-Jones & Grange, 2013). Our findings reveal that the longstanding healthcare information technology "design-reality gap" between technology and current practices involving information, processes, personnel skills, and structures (Heeks, 2006) can be bridged through the *situational improvisation of frugal telemedicine technology*. For example, our study suggests that on-site personnel can facilitate effective communication between underprivileged patients and remote physicians in technical and nontechnical ways.

Second, our study provides insights into the roles that telecamps can play at different levels to mitigate the health divide in rural areas of developing countries, thereby extending our understanding of the mechanisms through which technology can address the health divide in these contexts (Sein & Harindranath, 2004).

At the first level, videoconferencing can be used with a substitutive purpose at telecamps—that is, a virtual channel in a mobile setting can serve as a substitute for physician presence in the villages. Our findings suggest that the effective use of videoconferencing technology at telecamps requires providers to consider contextual factors, such as disease diagnostic complexity, patient healthcare needs fulfillment, and the facilitative roles of a third party (i.e., operators), and prevents a limited focus on physicians and patients only.

At the second level, videoconferencing technology can be used at telecamps to significantly improve local healthcare service capacity and access to professional healthcare services for underprivileged populations. In other words, videoconferencing as a frugal teleconsultation technology, combined with effective operators who enact multiple facilitative roles, can be used for *developmental* purposes in that it creates a new model of healthcare service delivery that is cost effective, leverages indigenous human capital (e.g., operators), and promotes the development of healthcare infrastructure without imposing unrealizable economic and technological demands for bleeding edge technologies or requiring the relocation of specialist physicians to villages.

At the third level, telecamp offerings potentially provide opportunities to generate *new structures for business and societal change*. A key insight from our work is that successfully offering telecamps requires operators to be capable of situational improvisation. Training and apprentice programs for operators should go beyond the technical operation of equipment and include improvisational roles. In the future, as part of their corporate social responsibility agenda, major hospitals and medical research institutes in less developed countries could partner with NGOs and other development agencies to offer telecamps for underprivileged populations.

Third, to the best of our knowledge, our study is among the first to demonstrate that complementarities can be realized in understanding complex technology use phenomena by combining *variance and process perspectives*. Through a variance perspective, we theorized two moderation hypotheses and applied OLS regression to test these hypotheses using survey data. Through a process perspective, we developed two coding protocols and applied them to code the video archives into event and operator role structures that unfold over the course of a teleconsultation session. In addition to inspecting the patterns of different communication events and multiple operator roles, we applied nonparametric statistics to differentiate events across physician and patient characteristics, multiple operator roles, and three medical categories. The two perspectives collectively helped us decompose the two critical elements of technology affordance and user effectivity in the affordance-effectivity framework in different but complementary ways. As such, the decomposed affordance-effectivity framework provided a nuanced lens for us to develop a pragmatic theoretical understanding of effective teleconsultation in the telecamp context.

6.2 Implications for Policy Makers and Hospital Management

For policy makers, our study offers insights into how frugal technologies can be deployed for cost-effective teleconsultation at telecamps in villages in less developed countries. Although rural areas in less developed countries have limited technological infrastructure and healthcare resources (Venkatesh & Sykes, 2013; Venkatesh et al., 2016), our study suggests that physicians can perform effective diagnoses through the use of frugal videoconferencing technology at telecamps. Policy makers could collaborate with hospital systems to provide cost-effective telemedicine services to underprivileged populations. For example, hospital systems, such as Apollo Hospitals in India, have equipment for teleconsultation services as well as physicians and operators with experience in providing quality healthcare services to underprivileged populations using telemedicine. Such hospital systems may serve as an important partner in implementing public policy initiatives related to broadening healthcare access through telemedicine.

For practitioners in hospital systems, our findings provide guidance for developing training programs for operators regarding facilitative roles that compensate for frugal technologies, constrained infrastructure, and communication barriers that may impede the effectiveness of teleconsultation. Operators' different facilitative roles tackle different communication barriers: the technician role supports physical examinations and involves assisting with technical issues like dermascopes, microphones, lights, and videoconferencing connections, and the physician and patient roles support verbal communication between physicians and patients regarding symptoms, clinical test results, and medication histories. Management in hospital systems could design comprehensive and systematic training programs for operators in both telecamps and franchised telemedicine clinics. These training programs would need to cover not only technical issues but also communication requests arising from the interactions among physicians, patients, operators, and technology. Moreover, different medical categories involve different requirements for operators' facilitative roles in physician-patient communication during teleconsultation. For example, dermatology requires operators to spend more time performing technician roles, whereas neurology requires operators to act more as interpreters for both physicians and patients. We suggest that hospital management allocate personnel, medical, and technical resources according to the diagnostic requirements of specific medical specialties. Hospital systems could also host telecamps that focus on certain medical specialties (e.g., neurology telecamps) to more effectively align interests among different telemedicine stakeholders.

6.3 Strengths, Limitations, and Future Research

Although our study effectively combines variance and process perspectives as well as quantitative and qualitative methods, it has some limitations. First, our study developed "middle-range theories that involve actors (with their intentions and skills) and technical objects (with their specific features)" based on the affordance insights from ecological psychology as well as those from the IS literature on traditional media and novel technology use (Strong et al., 2014; Volkoff & Strong, 2013, p. 822). However, our empirical context is quite unique—free telecamps for underprivileged populations. Future studies could consider the distinctive aspects of other telemedicine use contexts (e.g., nonmobile clinics, patients with varying socioeconomic statuses) and evaluate the generalizability of our findings in these contexts.

Second, according to the literature on medical interactions (Heath, 2006), diagnostic processes include three phases: social interaction, communication pertaining to diagnostic information, and decision-making. Our process analysis, however, only examined communication related to diagnostic information. In fact, we were scarcely able to identify events pertaining to the two other phases (social interaction and decision-making) in the video archives. This may be because, at the telecamps we studied, the physician assigned to a patient made decisions regarding diagnosis and prescribed treatment. Moreover, high patient throughput was a key objective of the telecamps, which constrained patients' social interaction with physicians and operators. Future studies should consider diagnostic processes in the two other phases in other telemedicine settings (e.g., telemedicine clinics) (e.g., Serrano & Karahanna, 2016).

Third, in our variance model, we focused on patient satisfaction as the outcome variable. Future research might examine additional dependent variables, such as patient preference for teleconsultation over in-person visits, repeated teleconsultation service consumption by patients, or word-of-mouth for teleconsultation services. As prior studies have generally assumed that telemedicine services have positive outcomes, researchers could investigate how and why frugal telemedicine solutions may increase the odds of adverse medical events and how solutions might be designed to prevent or achieve early detection of such events.

Fourth, we limited our focus to operators' multiple roles when examining physician-patient interactions during teleconsultation sessions at telecamps. We suggest that future research extend the discussion to the role of the broader support team. For example, HoWs can involve additional personnel (e.g., supervisory staff, drivers, operators, assistants) (see Appendix A). Although on-site operators are important for the effective delivery of telemedicine services, as suggested by our study, future research should evaluate how effective teams might be designed and managed for telecamps.

7 Conclusion

We proposed a decomposed affordance-effectivity framework to understand physician-patient communication in free telemedicine camps delivered in rural villages in less developed countries. We adopted a multiple-actor perspective and combined variance and process perspectives to investigate the phenomenon of interest. Using a variance perspective, we found that the actualization of telemedicine affordance—turning patient-perceived media richness into patient satisfaction—was contingent upon disease diagnostic complexity and patient healthcare needs fulfillment. Using a process perspective, we discovered that on-site operators' multiple roles served as compensatory user effectivity in actualizing telemedicine affordance at telecamps. Our study not only represents a significant advance in the emerging literature on technology affordance in the IS field but also provides practical insights for policy makers and hospital management regarding the effective use of frugal technologies to address societal problems related to healthcare and poverty.

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Appendix A: Free Telecamps in Rural India

A1. Apollo Hospitals Group

The Apollo Hospitals Group[16] is one of Asia's largest healthcare groups and had grown to more than 8,500 beds across 54 hospitals within 30 years at the time of the study in February 2012. As of July 2019, the group's size had further grown to 71 hospitals with 9,000 beds.

The Apollo Hospitals Group introduced telemedicine to India in 1999 and subsequently established the Apollo Telemedicine Networking Foundation (ATNF)[17] and Apollo TeleHealth Services (ATHS)[18] for its telemedicine programs. The ATNF is a not-for-profit organization, and ATHS is a company under Apollo Hospitals Groups; both aim to expand and provide quality healthcare services using telemedicine, particularly to rural areas in India and other developing and underdeveloped countries. Both ATNF and ATHS collaborate with the private and public sectors and the Indian central and state governments at the domestic and international levels to provide cost-effective, quality healthcare services.

ATNF and ATHS have emerged as leaders in the area of telemedicine in South Asia, connecting more than 135 peripheral centers, including 15 outside of India. At the time of the study in February 2012, ATNF and ATHS had provided more than 79,000 teleconsultation sessions in 25 different disciplines at distances ranging from 200 km to 7,500 km. As of July 2019, the number had reached 1.2 million teleconsultation sessions through large-scale public-private partnerships to scale access to healthcare through telemedicine.

A2. Expanding Healthcare Access with Free Telecamps in India

Mr. Sachin Pilot, then the Minister of State for Information Technology, organized a free telecamp in his constituency at Ajmer in February 2012. Commenting on the motivation for the camp, Mr. Pilot noted, "The basic idea behind the [free telecamp] project . . . was to ensure [the] presence of leading doctors at Ajmer so that poor and rural people could get basic treatment and consultancy from them."[19]

At the time of our study, ATNF and ATHS had conducted more than 10 free telecamps in partnership with the Indian central and state governments and not-for-profit organizations. These two-day free telecamps attracted as many as 50,000 underprivileged participants from rural areas. In the camps, reading glasses, hearing aids, wheelchairs, crutches, and medical kits were distributed to the needy in collaboration with medical equipment vendors. In addition, about 30,000 basic medical exams had been conducted free of charge in each health camp. ATNF and ATHS provided teleconsultation services through HoWs at the free telecamps, as described below.

A3. Hospital on Wheels Teleconsultation Services at Free Telecamps

Each two-day free telecamp deployed a HoW that was driven to the rural camp location. The HoWs used were Greyhound-like buses with the body divided into five cubicles. Each HoW was staffed with one senior supervisory staff member, one driver, one assistant to the driver, and five operators to serve the five cubicles. The operators were technology proficient and knowledgeable about the technological limitations and logistical challenges at the local site, knowledgeable about the local dialects and social norms, and knowledgeable about physicians' diagnostic approaches from remote sites.

Each cubicle had a set of videoconferencing equipment, a TV monitor, and a personal computer with a webcam for Skype video connectivity as a backup solution for the videoconferencing equipment. One of the five cubicles had a dermascope, which is a small handheld device connected to an auxiliary input on the videoconferencing equipment and works as a second camera. Dermascopes can take close shots of the skin for dermatological diagnoses and also serve as a light source for enhancing skin texture images. In addition, each cubicle had a leased line for internet connectivity with a static IP address. The minimum internet speed was 512kbps synchronous bandwidth (for both upload and download). The HoW and videoconferencing equipment usually used power from the local site where the free telecamp was held. A 5KVA uninterruptible power supply (UPS) system served as a backup source of power, and an additional power generator was also available for prolonged power outages.

[16] http://www.apollohospitals.com
[17] https://www.telemedicineindia.com
[18] https://www.apollotelehealth.com
[19] Source: https://www.apollohospitals.com/news/an-idea-whose-time-has-come-the-health-camp-at-ajmer

Once the equipment and network were set up, the cubicles were connected with physicians from Apollo Hospitals in Ahmadabad, Bangalore, Chennai, Hyderabad, and Madurai, covering more than 10 different specialties, including neurology, cardiology, pediatrics, orthopedics, dermatology, oncology, and sexual medicine. The teleconsultation schedules were created for physicians before the health camps took place so that physicians could allocate blocks of time to the camps in their schedules. During the camps, patients queued outside the HoW and took turns seeing appropriate physicians. Approximately 250 teleconsultation sessions were conducted through each HoW at the camps we observed.

A4. Costs and Benefits of Teleconsultation Services at Free Telecamps

Below, we present the (1) costs incurred by the hospital, (2) cost savings to patients participating in the free telecamps, and (3) benefits for local healthcare service personnel and peripheral franchisees.

A4.1. Hospital Systems: Cost of Teleconsultation Services at Free Telecamps

Table A1 reports the capital expenses and annual depreciation rates.

Table A2 reports the operating expenses for the camps held in Srirangam and Bodinayak in Tamil Nadu, South India, that were examined in our study. The average operational expenses per teleconsultation session in the two telecamps in our empirical investigation were 300 INR (less than 5 USD).

Table A1. Equipment and Depreciation Expenses

Hospital on Wheels (HoW)		
HoW	10,000,000	INR
Annual depreciation (25%)		
Road tax	400,000	INR (lifetime)
Vehicle maintenance	60,000	INR/year
Vehicle insurance	175,000	INR/year
Videoconferencing equipment		
Videoconferencing equipment	750,000 (150,000 * 5 cubicles)	INR
Annual depreciation (25%)		
Backup power generator		
Backup power generator	500,000	INR
Annual depreciation (25%)		
Notes: Expected lifetime: HoW = eight years, backup power generator = eight years. INR = Indian rupees.		

Table A2. Operational Expenses for the Srirangam and Bodinayak Camps

Travel	**11,286**	INR
Travel cost (fuel) per HoW	11	INR/km
Distance from Chennai to Srirangam	316	km
Distance from Srirangam to Bodi	197	km
Distance from Bodi to Chennai	513	km
Personnel[a]	**205,200 (51,300 * 4 days)**	INR
Driver	400*2	INR/day
Assistant to driver	250*2	INR/day
Daily allowance for 10 operational staff members	1,000*10	INR/day
Travel and hotel expenses for 10 operational staff members	4,000*10	INR/day
General supplies	**36,000 (9,000 * 4 days)**	INR
Diesel and electricity (Generator, videoconferencing equipment, and peripheral medical devices)	1,500	INR/day
Miscellaneous expenses (Food, security, promotional materials, etc.)	7,500	INR/day
Medical supplies[b]	**50,000 (25,000 * 2 camps)**	INR
Drugs dispensed	25,000	INR/camp

Notes: a. Specialist consultation fees were waived as the Apollo Hospital Group's participating consultants volunteered their time at no cost. b. Generic drugs were given for two to three days at the procured cost (there is as much as a 30% profit in drug sales).

A4.2. Patient Cost Savings

Patients realized cost savings from teleconsultation in three primary ways. First, they saved *travel costs*: at the time of study, a round-trip train ticket from Srirangam or Bodinayak to Chennai cost about 600 INR per passenger. Second, they saved on *lodging and meal costs*: ATNF estimated the cost for lodging and meals per patient in Chennai at 1,150 INR (accommodation: 900 INR per person per day; meals: 250 INR per person per day). Finally, they saved *lost wages* because they needed to take less time off compared to the time off that would be needed to make a trip to an urban hospital: ATNF estimated the average wage of camp attendees at 300 INR per person per day. Based on our survey data, around 40% of the teleconsultation patients attended the free telecamps alone; one or more friends and/or family members accompanied the other 60% of patients. An even higher percentage of patients from rural areas are likely to have someone accompany them for support when they travel to an unfamiliar location to interact with unfamiliar people for their healthcare, further reducing the level of lost wages through telecamps.

A4.3. Spillover Benefits

The provision of teleconsultation services at free telecamps generated multiple spillover benefits. First, physicians in urban areas expanded their understanding of healthcare issues among underprivileged populations in rural areas. Second, operators expanded their knowledge of (1) how to effectively improvise in unpredictable conditions (e.g., negotiating internet connectivity with local officials, switching to generators in a timely manner and reestablishing connectivity with remote sites during power cuts, switching to Skype-based teleconsultation when technical problems are encountered with the videoconferencing equipment/connectivity), and (2) how to effectively mediate between remote-site physicians and underprivileged patients with varying health needs, language capabilities, healthcare knowledge, and social norms. Third, the provision of telecamps initiated pilot projects involving cooperation among government agencies, nongovernmental organizations (NGOs), and hospitals to expand healthcare access to underprivileged populations in rural India.

A5. Photo Gallery

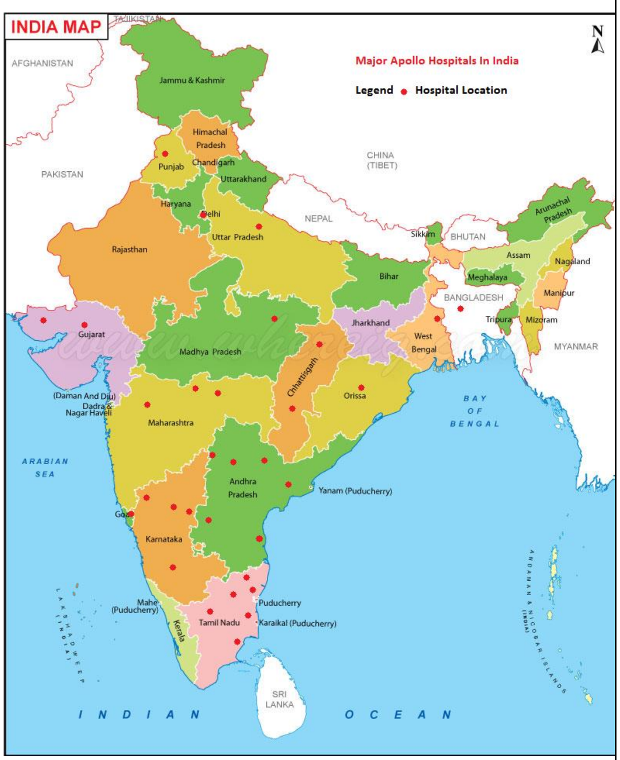
Apollo Hospital Locations	Apollo Telemedicine Network
	

Figure A1. Apollo Hospitals and Telemedicine Network

Location 1: Guwahati	Location 2: Kolkata	Location 3: Port Blair
		

Figure A2. Apollo's Franchised Telemedicine Clinics

Role as a technician	Role as a physician	
		
Operator faxing a prescription after a teleconsultation session.	Operator guiding the patient to do tandem walking to check her cerebellar coordination for a neurology diagnosis.	Operator connecting the electrocardiogram (ECG) from a telemedicine kit to aid the physical examination of the patient on the physician's behalf.

Figure A3. Operators' Facilitative Roles in Telemedicine Clinics

Health camps	Hospital on Wheels	Teleconsultation at health camps
		

Figure A4. Free Telecamps

Role as a technician	Role as a physician	Role as a patient
		
Operator adjusting the dermascope for a dermatology diagnosis.	Operator providing examination instructions for a neurology diagnosis.	Operator reading out test results on the patient’s behalf.

Figure A5. Operators’ Facilitative Roles at Telecamps

Appendix B: Details of the Variance Study

B1. Survey Sample Profile

Table B1. Sample Profile (Survey)

Category		Frequency	Percentage (%)	Category		Frequency	Percentage (%)
Age (Years)	< 20	35	16.20	Gender	Male	113	52.31
	21-30	40	18.52		Female	103	47.69
	31-40	33	15.28	Individual monthly income	None	9	4.17
	41-50	37	17.13		< 7,500 INR[b] (120 USD)	187	86.57
	51-60	29	13.43		7,501-15,000 INR	10	4.63
	61-70	22	10.19		15,001-25,000 INR	7	3.24
	> 70	20	9.26		25,001-50,000 INR	3	1.39
Education	None	3	1.39	Household monthly income	None	0	0.00
	Primary school	73	33.80		< 7,500 INR (120 USD)	189	87.50
	Secondary school	51	23.61		7,501-15,000 INR	13	6.02
	Higher secondary[a]	66	30.56		15,001-25,000 INR	10	4.63
	College	11	5.09		25,001-50,000 INR	4	1.85
	Master's or above	12	5.56				

Notes: (a) Higher secondary school: Grades 11 and 12. (b) INR: Indian rupees, 1 Indian rupee = 0.0180 USD

B2. Construct Measures

Table B2. Construct Measures

Construct names	Measures
Patient-perceived media richness (Dennis & Kinney, 1998)	PMR1: I could easily explain things to the physician in the teleconsultation session. PMR2: The communication conditions in the teleconsultation session helped me communicate quickly with the physician. PMR3: The communication conditions in the teleconsultation session helped the physician and me better understand each other.
Patient healthcare needs fulfillment (Ganapathy et al., 2016; Kummervold et al., 2012)	HNF1: I am able to afford healthcare costs. HNF2: I am able to obtain quality healthcare services. HNF3: I am able to obtain timely healthcare services.
Patient satisfaction with teleconsultation services (Sykes et al., 2011)	SAT1: I am very satisfied with the care I received in the teleconsultation session. SAT2: The medical care I received in the teleconsultation session was excellent. SAT3: The care in the teleconsultation session was just about perfect.

B3. Classification of Diseases and Frequency Counts of Patients in Low/High Complexity Groups

Table B3. Disease Diagnostic Complexity

Diagnostic complexity	Diseases reported	Frequency	Percentage (%)
Low	• Arthritis (23) • Asthma (12) • Cataract (4) • Depression (7) • Foot irritation (1) • Hearing impairment (8) • Hypertension (18)	73	33.8
High	• Back pain (1) • Dermatology (8) • Diabetes (18) • Gastric ulcer (9) • Hand pain (1) • Headache (6) • Heart disease (11) • Knee pain (44) • Leg pain (6) • Neck pain (1) • Neurology (28) • Orthopedics (1) • Other (4) • Psychiatry (1) • Seizure (3) • Thyroid (1)	143	66.2

Notes: The number of cases for each disease is reported in parentheses. The total number of cases was 216, which is the same as our sample size.

Appendix C: Details of the Process Study

C1. Sample Profile of Teleconsultation Video Archives

Table C1. Sample Profile (Video Archives)

Category		Frequency	Percentage (%)	Category		Mean	SD
Patient gender	Male	23	50.00	Patient age		45.50	17.50
	Female	23	50.00				
Disease categories (medical specialties)	Orthopedics	20	43.48	Physician experience	Total years in specialty	23.18	12.21
	Dermatology	10	21.74				
	Neurology	12	26.09				
	Other	4	8.69		Number of sessions at the camp[a]	12.07	5.86
Companion	No	41	89.13				
	Yes	5	10.87				

Notes: [a] Reported numbers are based on log transformation.

C2. Diagnostic Requirements in Teleconsultation for Different Medical Conditions

Table C2. Diagnostic Requirements in Teleconsultation

Diagnostic requirement	Tele-neurology	Tele-dermatology	Tele-orthopedics
Technology (media)	Important (usually requires higher bandwidth to identify movement disturbances) (2)	Very important (3)	Not important (1)
Clinical test	Very important: computerized tomography (CT) scan, magnetic resonance imaging (MRI), electroencephalography (EEG), electromyography (EMG), etc. (3)	Less important: blood tests (e.g., drug allergy) (1)	Very important: x-ray, CT scan, MRI (3)
Medication history	Important (but less than dermatology): history from attendant (2)	Very important (3)	Important (2)

Notes: Three-point scale: 1 = least important, 2 = important, 3 = most important.

About the Authors

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Krishnan Ganapathy is on the board of directors of Apollo Telemedicine Networking Foundation (ATNF) and Apollo TeleHealth Services, the largest and oldest multispecialty telemedicine network in South Asia. A former secretary and past president of the Neurological Society of India, he started telehealth in India two decades ago. Formerly an adjunct professor at Indian Institute of Technology Madras & Anna University, he is currently an emeritus professor at the Tamil Nadu Dr. MGR Medical University and a visiting professor at several universities. A past president of the Telemedicine Society of India, he is on the editorial board of the *American Telemedicine Association Journal* and other telemedicine and neurosciences journals. He has served as a mentor for MBA students from Harvard Business School, Yale University, and renowned Indian universities. Columbia University's School of International Public Affairs selected ATNF to demonstrate global best practices in telemedicine. Dr. Ganapathy was recently selected by the World Health Organization to be on the Roster of Digital Health Experts. He has presented 350 papers at national conferences, and 140 at international meetings, and has published 200 scientific papers and 10 book chapters.