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Information Separation in Service Supply Chains at the Bottom of the Pyramid: An Illustration through Telemedicine

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Research Paper

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Abstract

The bottom of the pyramid (BOP) consists of communities that reside in geographically remote areas and lack access to physical and technological infrastructure. Consequently, supply chains that distribute to and source from the BOP suffer from hindrances in information exchange between supply chain partners and are particularly vulnerable to information separation. The paper examines how service organizations operating at the BOP use ICT to reduce information separation in their supply chains. Noting the importance of and problems plaguing the delivery of healthcare services at the BOP, we use the healthcare services supply chain as the context for our study. We first draw from the literature on BOP supply chains and healthcare supply chains, to identify key information separation problems. We then develop, from secondary and published sources, a detailed case study on the BOP initiatives of one of the largest healthcare organizations in India. We analyze this case to reveal (1) particular ICT applied to healthcare supply chains at the BOP, (2) how these ICT reduce information separation in healthcare supply chains, and (3) developmental outcomes of information separation reduction. The study contributes to the emergent literature that addresses developmental impacts of ICT at the BOP. It provides, for practice and policy, key issues that private and public service providers must consider in order to build effective supply chain processes and delivery mechanisms at the BOP.

Keywords: Information separation; Bottom of the Pyramid; Supply chain management; Healthcare supply chain; Telemedicine

1. INTRODUCTION

The bottom of the pyramid (BOP) refers to the economic class of individuals whose per capita income is $1,500/year or less (Prahalad and Hart, 1999; Vachani and Smith, 2008). While the individuals at the BOP are associated with unrealized market potential (Prahalad and Hammond, 2002; Prahalad and Hart, 1999), they reside in geographically remote areas and lack access to physical and technological infrastructure,

leading to two distinct conditions. One, firms that want to market to BOP consumers experience difficulty in building effective distribution channels because they cannot effectively communicate demand and inventory with downstream supply chain partners (Prahalad and Hammond, 2002; Prahalad and Hart, 1999; Vachani and Smith, 2008). Two, firms that want to source from BOP producers find it difficult to communicate product specification and price information to them. That is, there are hindrances in information exchange between supply chain partners, in supply chains that distribute to and source from the BOP. Such a condition, known as *information separation*, exists when producers and consumers have asymmetrical or incomplete knowledge concerning products, services, and market conditions (Bartels, 1968). Supply chains at the BOP are thus particularly vulnerable to information separation.

Supply chains, in order to be effective, need to efficiently transfer both physical goods and information accompanying them. A number of development problems thus stem from information separation in BOP supply chains. First, lack of information on demand and inventories impedes distribution of goods such as essential consumables and critical services such as basic healthcare to BOP consumers (Vachani and Smith, 2008). Second, processes relating to citizen services such as land records registration and tax collection are difficult to implement. Third, BOP consumers and producers cannot access information that could potentially enhance their social and economic conditions such as employment opportunities, education options and potential markets/prices for their products. Consequently, the reduction of information separation is vital for supply chains at the BOP. The service sector is particularly affected by information separation because of the irreplaceable role that customers play in service provision (Lovelock and Gummesson, 2004) and consequent requirement for bi-directional flow of information (Meijboom et al., 2011) between subsequent stages of the supply chain. Quite simply, due to information separation, members of the BOP are unable to fulfill their role in successful service provision. The healthcare supply chain is particularly critical for communities at the BOP. The enormous population of BOP participants (Prahalad and Hammond, 1999) combined with the small number of available local medical facilities (Pal et al., 2005), can cause not only cause rapid spread of disease amongst the BOP population, it can also prevent delivery of basic hygiene and health related information

and services. BOP communities thus find it difficult to easily access healthcare, leading to potential conditions for poor health and hygiene.

Studies have noted that application of information and communication technologies (ICT) to supply chain processes is necessary for exchange of accurate and reliable information between supply chain partners in developed nations (Fawcett et al., 2007; Lambert, 2004; Frohlich and Westbrook, 2001; Rai et al., 2006; Malhotra et al., 2005). However, research has not looked at problems distinct to service supply chains at the BOP and application of ICT as means to address them. The purpose of this study is thus to examine how service organizations operating at the BOP can use ICT to reduce information separation in their supply chains. Noting the importance of and problems plaguing the delivery of healthcare services at the BOP, we use the healthcare services supply chain as the context for our study.

Applying the theoretical perspective of information separation, we first draw from the literature on BOP supply chains and healthcare supply chains at the BOP, to identify key information separation problems. We then develop, from secondary and published sources, a detailed case study on the BOP initiatives of one of the largest healthcare organizations in India. We analyze this case to reveal (1) particular ICT applied to healthcare supply chains at the BOP, (2) how these ICT reduce information separation in the healthcare supply chain and (3) developmental outcomes of information separation reduction for BOP members. The study contributes to the emergent literature that addresses developmental impacts of ICT at the BOP. In particular, using the theoretical lens of information separation, it highlights the role of ICT in reducing information separation between supply chain partners in healthcare supply chains (and in service supply chains in general) at the BOP. It provides, for practice and policy, key issues that private and public service providers must consider in order to build effective supply chain processes and delivery mechanisms at the BOP.

The paper is laid out as follows. We first provide literature background on information separation in BOP supply chains, healthcare supply chains at the BOP and use of ICT in them. We follow that with a description of methods and case study site. Findings are described next, followed by a discussion of contributions, limitations and future research.

2. THEORETICAL BACKGROUND

2.1. Information Separation in Supply Chains at the BOP

Information is a vital resource for strategic supply chain response (Fawcett et al 2007). In order for supply chains to quickly respond to changes taking place in their competitive environment, supply chain partners must be aware of newly generated information in the environment (Mendelson, 2000) and be able and willing to share information amongst themselves (Fawcett et al., 2007). In advanced economies, a major cause for information separation is absence of partner willingness to share information results in information separation (Muller and Gaudig, 2011). Supply chains at the BOP however are characterized by a number of inherent conditions that make sharing of information difficult and aggravate information separation as explained below.

First BOP communities reside in remote locations and face poor physical infrastructure. They are thus characterized by accessibility and distribution impediments (Vachani and Smith, 2008). Often the last link in the distribution side of the supply chain is a retail store owned by a BOP entrepreneur who does not have a structured mechanism for collecting, analyzing or transferring information on local demand conditions. Organizations find it difficult to connect with BOP supply chain partners and thus cannot collect, analyze, and distribute information (Fawcett et al., 2009) in a timely manner. They also face hurdles in their attempts to tap into these remote areas and provide BOP members with product and service information. Taken together, these conditions result in inefficient downstream delivery of materials and/or services, and the upstream flow of information between partners, making supply chain coordination and integration very difficult to realize (Frohlich and Westbrook, 2011; Schoenerr and Swink, 2011).

Second BOP communities cannot afford to use advanced telecommunication technologies and are faced with a digital divide in terms of poor technological infrastructure and very limited access to communication facilities such as telephones and Internet (Ahmed, 2007). These conditions prevent them from plugging in to information sources other than those that are the broadcast type such as television. BOP consumers

and producers find it nearly impossible to proactively search for information on products, prices and potential customers. BOP members are therefore characterized as information deprived (Banerjee, 2005).

Third, BOP consumers and producers have high levels of illiteracy and in particular low levels of computer skills (Vachani and Smith 2008). They often require the help of other human intermediaries to be able to use ICT (Cecchini, 2003). However, poor physical infrastructure and low local education levels limit access to such human intermediaries. Even BOP citizens who are entrepreneurs face information separation, as they do not have accessibility to guidance, technical advice, funding, and support services that are easily accessible in advanced economies (Prahalad and Hammond, 2002). The resulting lack of access to information compounded with the low literacy of BOP members ultimately causes a widening of separation of communities residing at the BOP, from the more mainstream source of information. It also results in a significant gap in information between supply chain members and their BOP partners. BOP consumers and producers find it difficult to assess the value and price of products and services and are vulnerable to price exploitation (Vachani and Smith, 2008).

Based on the above we infer that supply chains operating at the BOP are vulnerable to information asymmetries and face compelling reasons for information separation due to their rural location, local economic climates, and inability to connect with the developed world. We know that IT infrastructure facilitates the information flow required for effective flow of products and services in the supply chain (e.g. Rai et al., 2006). However, expensive and sophisticated intra-organizational systems are necessary for the sharing of vast, high quality, confidential, and coordination-based information between supply chain partners in order to enhance operational efficiency and market knowledge created by other chain members (Malhotra et al. 2005). The physical, technological, skill and resource barriers associated with BOP communities and supply chain partners makes development, implementation and maintenance of such systems difficult.

2.2. Healthcare supply chains and the importance of healthcare at the BOP

The healthcare supply chain can be defined as "the information, supplies, and finances involved with the acquisition and movement of goods and services from the supplier to the end user in order to enhance clinical outcomes while controlling costs" (Schneller and Smeltzer, 2006, p. 30). From a macro perspective, the healthcare supply chain consists of various organizations whose role is to develop healthcare, provide financing for service provision, and the delivery of healthcare (Sinha and Kohnke, 2009). Specifically, key members of this supply chain are for-profit organizations such as medical device manufacturers and pharmaceutical and biotechnology companies who reside furthest upstream and are responsible for development of service bundles (Kumar et al, 2008; Sinha and Kohnke, 2009). Next are the insurance companies and banks, who are responsible of providing patients with financial coverage and health savings accounts (Sinha and Kohnke, 2009). The downstream portion of the supply chain is where healthcare is delivered, and it is mostly comprised of non-profit organizations such as home health care, clinics, and hospitals (Gehmlich, 2008; Sinha and Kohnke, 2009). The last component of the healthcare supply chain is the patient his/herself.

Unlike supply chains from a manufacturing perspective, where information mostly only flows upstream (Frohlich and Westbrook, 2001), service sector chains such as the healthcare supply chain are characterized by bi-directional information flows and customers who are always part of the production process (Meijboom et al., 2011). That is, customers have the irreplaceable responsibility of being suppliers of important input into the production of service, ultimately to "influence the whole process of service provision, from specification of the desired service to actual service delivery" (Meijboom et al., 2011, p. 168; Sampson, 2000). This is referred to as the customer-supplier duality (Sampson, 2000). Thus, healthcare provision is successful only when the patient is able to supply upstream healthcare partners such as insurance companies and caregivers with health-related information, so that healthcare providers can provide appropriate healthcare solutions in return. However, this customer-supplier duality is all but impossible to create at the BOP due to lack of connectivity from poor physical and technological infrastructure. BOP consumers of healthcare services are thus able to provide very little information to upstream partners regarding their medical conditions,

because of which community epidemics and individual diseases have gone rampant in BOP societies and have caused the gap between supply and demand of quality healthcare to reach alarming proportions (Sinha and Kohnke, 2009). Also adding to this gap is the large BOP participant population to local medical facilities ratio, low teledensity and technological literacy, and historically substandard delivery of healthcare (Pal et al., 2007).

2.3. Use of ICT in healthcare supply chains at the BOP

The use of ICT in healthcare supply chains at the BOP can enable bi-directional information flow between i.e. BOP patients and healthcare facilities (Fawcett et al., 2007), thus potentially reducing information separation. Access to relevant sources of information is noted as a key essential of healthcare delivery and enables the delivery of diagnosis and treatment (Sinha and Kohnke, 2009). It would allow BOP participants to obtain information concerning their own medical conditions as well as products and services. Moreover, once access through ICT is established, information exchange between healthcare providers (hospitals, doctors, clinics, etc.) and BOP members can occur. For example, telemedicine models support the upstream transmission of BOP patient information necessary for diagnosis, and the downstream transmission of post-consultation details that inform the BOP patient of appropriate medicines, treatments, and future prevention procedures (ITU, 2011). Essentially, such information flow can enhance control, decision-making, and coordination among all members of the supply chain (Armstrong and Sambamurthy, 1999), and can result in fewer treatment errors, smaller variation in care, electronic medical record security, and more clinician time spent on delivery care to patients (Thompson, 2004; Bauer and Ringel, 1999) at the BOP. It also had the potential to aid in disease identification and diagnosis. Indeed the use of telemedicine in remote areas of the world has enabled patients to receive quality healthcare without traveling long distances, increased their awareness of diagnosis and treatment of their medical condition, and saved them money (ITU, 2011).

Based on the survey of the relevant literatures reported above, we note that (1) supply chains at the BOP are subject to high levels of information separation, (2), difficulties in

delivering healthcare at the BOP stem largely from information separation facing healthcare supply chains, and (3) the use of ICT in healthcare supply chains at the BOP can potentially reduce information separation. We also note that the supply chain literature does not examine information separation in BOP supply chains. Furthermore, while the ICT for development literature reports on telemedicine initiatives in rural areas, it does not provide a theoretical framework for understanding *how* the use of ICT can benefit healthcare supply chains at the BOP. Thus, the objective of this study is to uncover the mechanisms through which information separation can be reduced in supply chains at the BOP through use of ICTs. In addition, we also explain the associated outcomes such reduction. As is evident from the above, the difficulties facing healthcare supply chains at the BOP stem largely due to information separation. Thus, the healthcare supply chain represents a fruitful context through which information separation in service supply chains at the BOP can be examined.

3. METHODS

3.1. Methodology and Site Selection

To understand *how* the role that ICTs play in reducing information separation in supply chains at the BOP, we adopted a qualitative approach. In particular our intent was to examine: (a) the use of ICT in BOP healthcare initiatives in its real-life context and (2) conduct an in-depth analysis of potential information separation reduction mechanisms, both of which call for qualitative approaches (Yin, 2003). Previous studies that examine the application of ICT to developmental initiatives have used such approaches primarily because of the breadth and complexity of the phenomenon involved.

We chose the Apollo Telemedicine Network Foundation (ATNF), a healthcare provider that has successfully provided healthcare service to BOP communities in India and Africa through telemedicine, as the illustrative site for our study. This site was selected for the following important reasons. First, ATNF has operations in multiple BOP markets, i.e. in India and Africa. Secondly, ATNF has successfully demonstrated how to deploy ICT to tap into BOP areas and secure the participation of BOP members into the healthcare supply chain. Third, ATNF's telemedicine initiative has consequently transformed BOP

areas and empowered local residents. Lastly, ATNF has generated a positive reputation on both domestic and global levels (ATNF1, 2012; ATNF2, 2012), exemplifying their leadership in providing high quality, available, and affordable healthcare service to remote rural locations.

3.2. Data collection and analysis

We collected secondary data on the initiatives of ATNF in BOP communities. In particular we examined descriptions of how ICT was applied to various supply chain processes and interactions between the supply chain stages. We also looked at the motivation for implementing these initiatives and the outcomes for ATNF and BOP communities. The data sample consisted of a total of 11 different articles from 10 different sources that describe healthcare delivery initiatives of ATNF in rural populations in general, and BOP communities in particular. The data sources for these articles include refereed academic journal articles (n=4), corporate websites (n=3), and publications/white papers from international developmental agencies and health organizations (n=3). The details of our sample are shown in Table 1 below. The keywords used in our search included: telemedicine, bottom of the pyramid, information technology, information technology, for development, supply chain management, and service management.

Table 1. List of Data Sources

Category of Data Source	Number of Articles
Refereed Academic Journal Sources	
International Journal of Services and Technology Management	1
Telemedicine and e-Health	1
Technology	1
IEEE Transactions on Information Technology in Biomedicine	1
Corporate Website Sources	
www.apollohospitals.com	1
www.telemedicineindia.com	2
www.moneycontrol.com	1
International Developmental and Health Organization Sources	
ACCESS Health International	1
International Telecommunications Union	1
World Health Organization	1
Total Number of Articles in Sample	**11**

Our data collection yielded several pages of secondary text, which we coded. We interpreted the data in bottom-up, grounded and exploratory fashion (Strauss and Corbin 1998) in line with suggested principles (Eisenhardt, 1989; Yin, 2004). We found three groups of codes. The first represented the capabilities for particular systems and technologies that were implemented at various stages of the healthcare supply chain. The second included mechanisms and processes through which ATNF reduced information separation. The third consisted of descriptions of developmental outcomes from reduction of information separation, for BOP communities. The analysis process was iterative and utilized a combination of axial and open coding, wherein we identified initial codes for each group (open coding) and compared the data with them, categorizing the latter under existing codes (axial coding) if a conceptual similarity was found, and identifying a new code otherwise.

4. BRIEF DESCRIPTION: APOLLO TELEMEDICINE NETWORK FOUDNATION (ATNF)

The Apollo Telemedicine Network Foundation (ATNF) is a non-profit organization under the umbrella of the Apollo Hospitals Group in India. In 1999, the organization was the first to establish a rural telemedicine center (ATNF1, 2012). The objective of the organization is to use telemedicine to provide healthcare of global standards (ATNF1, 2012), especially to those individuals residing in BOP areas of rural India and other underdeveloped regions around the world (Ganapathy and Ravindra, 2009). India has one of the world's largest healthcare industries in the world (Ganapathy and Ravindra, 2009) and is a notable global medical tourism destination (Lagace, 2007), Indian BOP participants (approximately 700 million Indians) lack direct accessibility to secondary and specialist medial knowledge (Ganapathy and Ravindra, 2009). BOP participants located in rural India have asymmetrical knowledge of products, services, and market conditions with respect to accessible, high quality, and cost-efficient healthcare. Through telemedicine, ATNF has been able to successfully use ICTs to reduce this informational separation.

Telemedicine, as defined by the World Health Organization (WHO), is "the delivery of health care services, where distance is a critical factor, by all health care professionals

using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities" (WHO, 2010, p. 9). As is evident from this definition, information is the fundamental unit of exchange in telemedicine, which requires implementation of sophisticated ICTs. ATNF demonstrates how deployment and utilization of such technologies enabled the reduction of information separation in the healthcare supply chain, resulting in improved patient care, and standardized clinical procedures. It also strengthened medical training and cost-efficiency and brought together clinicians and specialists from various parts of the world to provide healthcare services to BOP members (ATNF1, 2012).

We describe below, our findings from the ATNF case in the context of our research question.

5. FINDINGS

Figure 1 depicts the findings from the study. In the general sense we find that various types of ICT, deployed in the healthcare supply chain reduced its information separation, through four key mechanisms. Two developmental outcomes emerged for BOP members because of information separation reduction. We discuss the details of our findings below.

5.1. ICT used in Healthcare Supply Chain at the BOP

ANTF adopted a number of different types of ICT in its supply chain processes. They could be grouped into three categories that are deployed respectively in (1) customer interface processes, (2) medical data capture and transfer processes and (3) medical diagnostic support processes. ICT for the first category included telecommunication technologies such as VSAT and ISDN lines and information kiosks that connected BOP communities to medical experts in urban areas (Ganapathy and Ravindra, 2009). Also included in this category were videoconferencing tools such as web cameras, voice-enabled poly-cameras, microphones, speakers, and document

cameras (Bowonder et al., 2005), and software applications that allowed for access to remote health-related information sources from the patients' homes or from mobile places such as ambulance. These were deployed in healthcare initiatives such as the Virtual Healthcare at Home and Apollo Emergency Care (Hospital on Wheels) initiatives (Ganapathhy and Ravindra, 2009; ATNF1, 2012; Apollo, 2012; Bollineni, 2011; MoneyControl, 2007). Those for the second category included electronic biomedical equipment such as x-ray machines and electronic stethoscopes, ultrasound and electrocardiogram machines that captured and transmitted patient information to remote doctors for tele-consultations (Bollineni, 2011; Bowonder et al., 2005). ICT in the third category included decision support applications that aided in disease management, disaster management, knowledge management, complex interpretation and second opinion (ATNF1, 2012).   ,
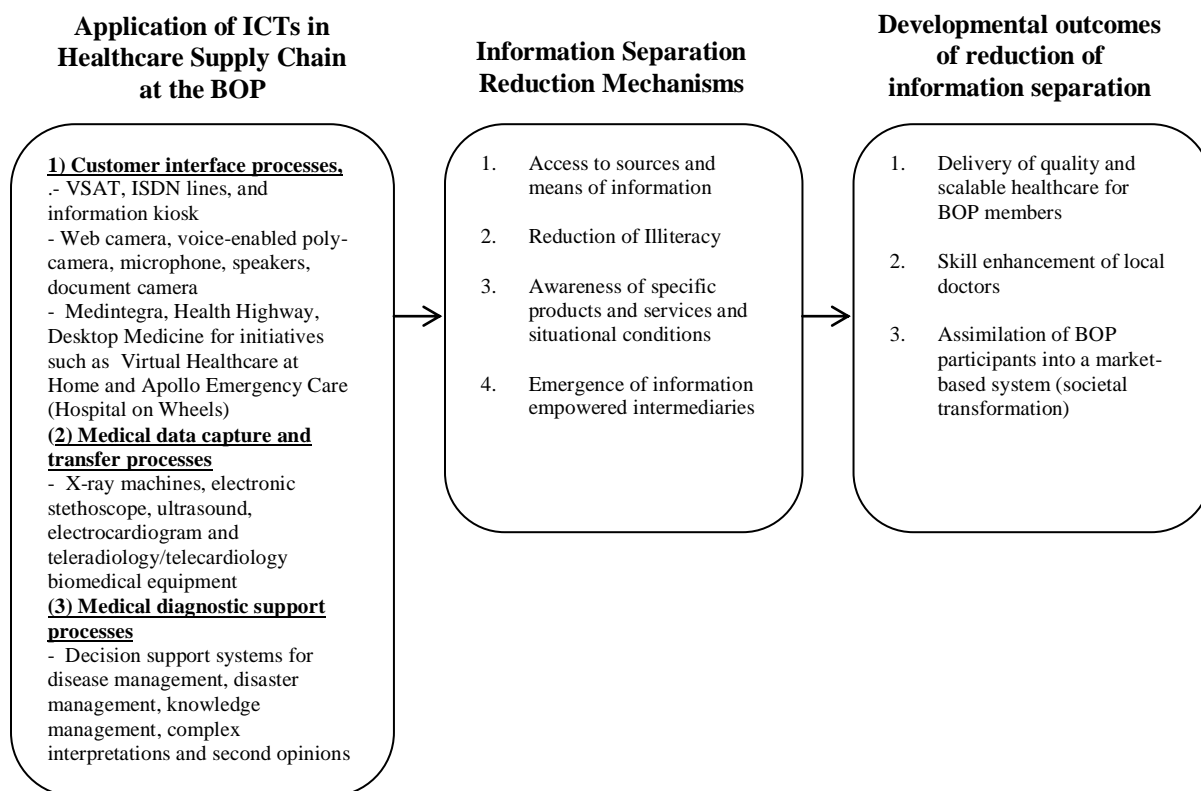
Application of ICTs in Healthcare Supply Chain at the BOP

1) Customer interface processes,
.- VSAT, ISDN lines, and information kiosk
- Web camera, voice-enabled poly-camera, microphone, speakers, document camera
- Medintegra, Health Highway, Desktop Medicine for initiatives such as Virtual Healthcare at Home and Apollo Emergency Care (Hospital on Wheels)
(2) Medical data capture and transfer processes
- X-ray machines, electronic stethoscope, ultrasound, electrocardiogram and teleradiology/telecardiology biomedical equipment
(3) Medical diagnostic support processes
- Decision support systems for disease management, disaster management, knowledge management, complex interpretations and second opinions

Information Separation Reduction Mechanisms

1. Access to sources and means of information
2. Reduction of Illiteracy
3. Awareness of specific products and services and situational conditions
4. Emergence of information empowered intermediaries

Developmental outcomes of reduction of information separation

1. Delivery of quality and scalable healthcare for BOP members
2. Skill enhancement of local doctors
3. Assimilation of BOP participants into a market-based system (societal transformation)

Figure 1. Information Separation in Healthcare Supply Chains at the BOP

5.2. Information Separation Reduction Mechanisms

There were four mechanisms through which ICT reduced information separation that emerged from our data analysis. These mechanisms include (1) Providing access to sources and means of information, (2) Reduction of illiteracy, (3) Increasing awareness of situational conditions and specific products and/or services, and (4) Presence of information intermediaries.

(1) Access to sources and means of information: The pervasiveness of rampant disease in remote Indian villages significantly outweighs the number of hospitals and the number of available and skilled human capital, ultimately causing a large and increasing gap between supply and demand of accessible healthcare (Bollineni, 2011). A significant part of this is due to lack of access of BOP members to basic disease and hygiene related information, information that is relatively more easy to access by non-BOP individuals living in the urban areas. ATNF leverages telemedicine to help shrink the digital divide and enable BOP members obtain the technology necessary to gain access to this sort of information from upstream healthcare providers, this breaking down the barriers to information distribution. In March of 1999, ATNF initiated the *Aragonda Project* and became the first organization in the world to use ICT to deliver healthcare to remote village citizens (Ganapathy and Ravindra, 2009). Located 250 miles away from the main offices of Apollo Hospitals in Chennai, the rural village of Aragonda had been troubled by 2 factors related to healthcare: (1) the pervasiveness of diseases such as malaria (Pal et al., 2005), and (2) the small percentage of local registered medical practitioners (Pal et al., 2005; Ganapathy, 2002). It was essential for Aragonda citizens to have access to sources of information that would increase their awareness of their health conditions and help to correctly screen, diagnose, treat, and even prevent diseases.

With the aid of the Indian Space Research Organization and Government of India's Department of Space, ATNF converted a local Aragonda hospital into India's first telemedicine center (Pal et al., 2005; Ganapathy and Ravindra, 2009) and the world's first VSAT-enabled rural village hospital (ATNF1, 2012). This telemedicine center provided BOP communities in Aragonda with access to two critical sources of information. Using

ICTs, ATNF provided BOP communities in Aragonda with access to two critical sources of information. First, VSAT and videoconferencing technology allowed BOP healthcare service consumers to have direct communication with the specialists located in Chennai, allowing for real-time teleconsultations through kiosks (ATNF1, 2012; ATNF2, 2012; Bowonder et al., 2005). Second, it provided BOP members with direct access to the centralized databases via VSAT where their electronic medial records (EMRs) and post consultation details (PCDs) were stored (ATNF1, 2012; ATNF2, 2012; Bowonder et al., 2005). Patients used this information to understand and track their medical conditions and ask questions of doctors, becoming more active participants in healthcare service delivery and overcoming that lack of supplier customer duality that was noted in Section 2.2. ATNF replicated this telemedicine model in many other remote rural areas in 116 centers in India, 7 across other remote areas of Asia, and 50 telecenters across BOP areas of Africa (ATNF1, 2012; ATNF2, 2012).

Collaborating with network software organizations such as Cisco, ATNF deployed applications in customer interface processes to provide two additional points of access for rural BOP participants. The first initiative was *Virtual Healthcare at Home*, where the software was installed on a special telemedicine kit and taken to the homes of rural patients, allowing patients to have around the clock access to available consultants (ATNF1, 2012). The second initiative *Apollo Emergency Care*, had desktop telemedicine software installed within emergency vehicles such as ambulance vehicles, VSAT-enabled buses (i.e. Hospital on Wheels) (Bollineni, 2010; ATNF1, 2012), and emergency helicopters; teleconsultations could still take place and information can be accessed while patients with serious conditions are in transit. Additionally, ATNF partnered with IBM to deploy the *Health Highway* initiative (MoneyControl, 2007), a network connecting over 1,000 primary, secondary, and tertiary care centers and hospitals (ITU, 2011 to give all healthcare delivery entities within the network, interoperable access to patient records (Ganapathy and Ravindra, 2009, p. 583).

 (2) Reduction of Illiteracy: By reducing illiteracy, information separation in the healthcare supply chain is reduced because BOP members can then obtain and assimilate relevant medical information.

Local medical practitioners in BOP villages lack the level of skill and education of their remote hospital counterparts (Bollineni, 2011), thus making training and education important. While the teleconsultations provide informational and personal benefits to the patients, they also serve as learning and training mechanisms for local physician at the village care centers. Because of the implementation of sophisticated ICTs, local nurses and other health workers can consult Apollo network experts and be guided remotely during teleconsultations (WHO, 2010). Furthermore, in conjunction with videoconferencing software, ATNF uses a disease management module so that rural-residing health workers can also learn about trending diseases in their respective regions and how to correctly identify symptoms and decide on the appropriate treatment (ATNF1, 2012). ATNF's telemedicine platform was also used to reduce illiteracy concerning general personal and community health issues for BOP areas through community teleconferences.

(3) Awareness of specific products and services and situational conditions: A third mechanism for information separation reduction was to provide BOP consumers with information on (1) specific treatment options available to them and (2) contextual community health-related conditions prevalent within BOP communities. Tele-consultation was the main avenue for providing such information. ICT deployed at the village telemedicine consultation centers (such as poly-cameras, web and document cameras, microscopes, microphones, speakers) combined with computer connected telemedicine equipment such as x-ray and electrocardiogram machines, and electronic stethoscopes enabled patient-specific medical information to be transmitted to Apollo specialty centers in a comprehensive and clear format (Ganapathy and Ravindra, 2009, Bowonder et al., 2005). This format can include text, images (i.e. images produced by x-ray machines, MRI and CT scans, and ultrasound audio (e.g. heartbeat transmitted through electronic stethoscope), and video (Bollineni, 2011). The remote specialist can

thus become aware of patient medical problems, arrive at a diagnosis and devise a treatment plan and advise the patient on available options.

ANTF has also enabled both specialists and BOP citizens to be aware of the community health-related conditions that are prevalent within their villages through the deployment of ICT that support three types of processes. These include (1) *Disease Management*, whereby trending diseases can be identified by region and action plans formulated to identify and treat them, (2) *Disaster Management*, whereby specialists could contain and prevent the spread of rampant diseases during natural calamities (ITU, 2011; ATNF1, 2012), and (3) *Knowledge Management*, where healthcare-related information was stored on the centralized database and could be accessed by Apollo network partners (ATNF1, 2012). Using this information, specialists enhance their own awareness of important health issues at the BOP and, in turn, enhance the awareness of the rural communities.
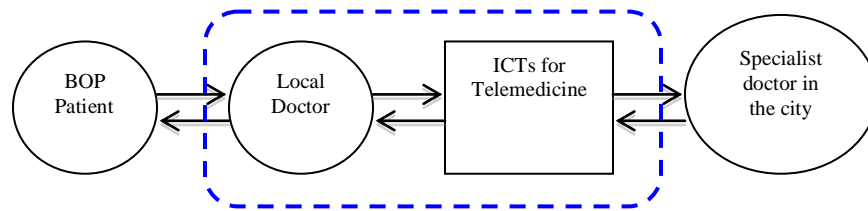
(4) Emergence of information empowered intermediaries: Information intermediaries within supply chains serve to reduce information separation between producers and consumers can (Spulber, 1996). Prior to introduction of telemedicine the primary information intermediaries that existed between Apollo doctors in the urban areas and rural BOP patients were the local village doctors, as shown in Figure 2. Due to the gap in literacy that exists between providers and consumers of healthcare services communities (WHO, 2010; Bollineni, 2011; Ganapathy and Ravindra, 2009), local village doctors need to be present during teleconsultations to not only operate the technologies, but to also interpret and engage in sense making between the patient and the specialist (ATNF1, 2012). Furthermore, the village doctors play the critical role in describing the telemedicine concept to BOP citizens and making the patient feel comfortable with this form of healthcare delivery (Bowonder et al., 2005). Their effectiveness as information intermediaries and the consequent impact on the quality of healthcare depends on their expertise and ability to interact with the city doctors. Because telemedicine was absent, local doctors could access expert advice and guidance from remote specialist only if they physically traveled to the city, or if specialists traveled to the village. Because this was

highly unlikely to transpire, the local doctor was an *information-deprived intermediary* that could not facilitate delivery of quality healthcare to the patient.

After implementation of ATNF's telemedicine model, as shown in Figure 2, local doctors were supplied with information kiosks with direct and instant access to remote specialist advice. Now the local doctors became *information-empowered* intermediaries, and were able to close the gap in the supply and demand of quality healthcare.
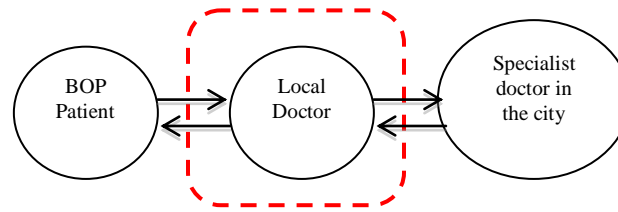
Local Doctor as an Information-deprived intermediary before ATNF telemedicine implementation

Local Doctor as an Information-empowered intermediary after ATNF telemedicine implementation

**Figure 2. Information intermediaries before and after
ATNF telemedicine implementation**

Further is also possible for these specialists to serve as information intermediaries if the medical condition of a rural BOP citizen warrants additional expertise from other specialists in the Apollo network (not depicted in Figure 2). For this reason, ATNF telemedicine model supports complex interpretation and second/special opinions (ANTF1, 2012). Complex interpretation is used when village patients have a complicated medical condition, and to ensure correct diagnosis and treatment, the expert

opinion of another team of medical specialists who may be geographically displaced from the tertiary care facility is requisite (ATNF1, 2012). Second/special opinions involve the additional expertise of a single specialist to discuss treatment plans with tertiary experts, village doctors, and village patients (Bowonder et al., 2005). With the exception of face-to-face communication between village patient and the village doctor, the communication that takes place between humans is always intermediated by ICT.

5.3. Outcome of reduction of information separation
we find that reduction of information separation results in four outcomes that include (1) delivery of quality and scalable healthcare for BOP members, (2) education of local doctors, (3) empowerment of BOP members and (4) their assimilation into market based exchange systems.

Delivery of quality and scalable healthcare for BOP members
We find that information separation reduction on a large scale in service supply chains, improves the quality, cost and scalability of the service that is delivered. ATNF has reduced information separation for thousands of BOP participants, performing over 71,000 teleconsultations in 25 different specialty disciplines (ATNF1, 2012 (Ganapathy and Ravindra, 2009; Ganapathy, 2005). Apollo specialist doctors have conducted these teleconsultations over distances ranging from 100 miles to 4,500 miles (ATNF1, 2012), making distance an irrelevant issue concerning the accessibility of medical information for BOP areas. Essentially then, ATNF, by reducing information separation, created a scalable distribution channel to reach large BOP markets, by eliminating the relevance of physical infrastructure. Healthcare (and in general, service) supply chains can become more easily scalable when they can render transportation and lodging of patients unnecessary (Sinha and Kohnke, 2009).

Skill enhancement of local doctors
An interesting by product was education of local medical personnel on appropriate techniques (ATNF1, 2012) and their enhanced motivation for elevating computer literacy (Ganapathy, 2002). Local physicians learned how to operate technologies for digital

imaging and to take and send x-ray and ultrasound images to Apollo specialist doctors in the cities (Ganapathy and Ravindra, 2009). They also learned to transmit patient data captured in various forms them via VSAT/ISDN to remote experts (Bollineni, 2011). Such training/informative activity has raised the level of computer/technological literacy of locals so that no only can they deliver quality healthcare services, but also so that they can learn from each other and raise the literacy of their respective communities. We thus find that information separation reduction in the healthcare supply chain enabled local practitioners to be more empowered, independent and valuable to the patient by enhancing their skills and services offered (WHO, 2010).

Assimilation of BOP participants into a market-based system (societal transformation)

Finally, we find that reducing information separation in healthcare supply chains at the BOP helps assimilate BOP members and local doctors into a mainstream healthcare system, promotes community health, and improves skills and education of local doctors. ATNF uses their telemedicine initiatives to conduct community education programs about nutrition, village sanitation, pregnancy health and drinkable water (ANTF1, 2012). They also use them to bring private health insurance to BOP populations, as well as monitor of diseases and epidemics by region (ATNF1, 2012). In doing all of this, information separation mechanisms promote human development in general at the BOP (WHO, 2010).

6. Contributions, Limitations and Conclusion

This study makes a number of theoretical contributions. First, we examine service supply chains, specifically the healthcare supply chain, at the BOP through the theoretical lens of information separation. In doing so, we suggest a framework for understanding developmental problems and information asymmetries that plague these supply chains and identifying the alleviating role of ICT. Secondly, we identify four mechanisms through which the use of ICT can reduce information separation between BOP participants and upstream healthcare supply chain partners. Thirdly, we suggest three

developmental outcomes from information separation reduction. While studies acknowledge problems in service supply chains that reach out to remote and poverty ridden communities, few, if any, provide frameworks by which such problems can be understood and tackled. By adopting the information separation perspective, we provide a hitherto unexamined viewpoint for understanding why supply chains at the BOP are not efficient and how the use of ICT can address the inefficiencies. We also suggest that separation of information separation in the healthcare supply chain is a potential harbinger of positive developmental outcomes at the BOP.

The practical value of the results reported in this paper lies in providing service organizations operating at the BOP, guidelines for reducing information separation between supply chain partners and ultimately enhancing the efficiency of their supply chain processes and potentially creating positive developmental outcomes. Policy makers for instance can apply the findings to e-government contexts and utilize the four information separation mechanisms as a checklist to assess, prioritize and eliminate information separation in supply chains for government services.

An important limitation of this paper is that our conclusions are based on a single case study of telemedicine implementation garnered from published secondary data. Wider theoretical generalization of results would require primary data from multiple service contexts. That said however, it is important to note that bi-directional exchange of information is a key characteristic of any service supply chain. The application of the information separation framework has thus enabled us to indentify four generalizable mechanisms by which supply chains at the BOP can me made more effective. While the specific developmental outcomes from these mechanisms may vary for different service industries, the pathways from the mechanisms to the outcomes are also fairly generalizable and can be used to analyze other types of BOP service supply chains such as banking and e-government. Thus, examining the reduction of information separation in supply chains at the BOP from the context of the healthcare supply chain provides insights that can be used by future research as a reasonable starting point to conduct more detailed studies on other service-sector supply chains at the BOP.

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