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Along with the rapid economic development in the past twenty years, China has paid considerable attention to public health in rural areas and has basically addressed issues concerning the establishment of community-based medical systems and public medical insurance systems. However, health problems continue to be of major concern for many farmers. The main reason is lack of appropriate medical resources in rural areas. Hence many diseases are not diagnosed or controlled during the early stages resulting in serious risks, demanding urgent interventions.

One of the major approaches to solving this problem is to promote the adoption and diffusion of new technologies in underserved population. Advanced technologies like Information and Communication Technology (ICT) such as mobile technology, biotechnologies and nanotechnologies are greatly helping the underserved people. For

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OVERVIEW OF LITERATURE RELEVANT TO INFORMATION AND COMMUNICATION TECHNOLOGY BASED HEALTHCARE DESIGN IN RURAL CHINA

example, according to observation from EU (www.nuadu.org), we believe that applications of state of the art ICT technology can contribute towards solutions for person centric portable and fixed appliances as well as end-to-end services operated by care providers.

However, even though the approach is clear, many detailed unknown and misunderstanding still exist in the process of the technology transformation. The biggest challenge in providing healthcare design for rural areas is to create intentional changes in rural China through the creation of new products and services. Mostly, designers face fuzzed design constraints such as culture and entrepreneurs for this kind of problems, or the so-called "wicked problems" (Rittel and Webber, 1974; Buchanan, 1992).

Definition

1. Information and Communication Technology (ICT)

ICT is an acronym that stands for "Information and Communication Technologies" and is used often in the context of "ICT roadmap" to indicate the path that an organization will take with their ICT needs. Information Technology Association of America (ITAA) defined ICT as (Adelman, 2000): *The study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware.*

As it pertains to technology, ICT spans a wide variety of areas that include but are not limited to Processes, Computer Software, Computer Hardware, Programming Languages, and Data Constructs. In short, anything that renders Data, Information or perceived Knowledge, in any visual format whatsoever, via any multimedia distribution mechanism, is considered to be a part of the domain space known as ICT.

Today, the term information has ballooned to encompass many aspects of computing and technology, and the term has become very recognizable. ICT professionals perform a variety of functions that range from installing applications to designing complex computer networks and information databases. A few of the duties that ICT professionals perform may include data management, networking, engineering computer hardware, database and software design, as well as the management and administration of entire systems. Information technology is starting to spread farther than the conventional personal computer and network technology, and more into integrations of other technologies such as the use of cell phones, televisions, automobiles, and more, which has increased the demand for facilitating jobs.

ICT is often considered as a form of value creation, according to Bird (2010). He proposed that with the growing competitiveness between organizations ICT enables value creation which is heavily dependent upon the alignment of technology and business strategies. It requires business and technology management to work as a creative, synergistic, and collaborative team instead of a purely mechanistic span of control.

2. Healthcare

Various definitions of healthcare (or health care) can be referred in literature. For instance, Bond (1994) defined healthcare in his book 'Sociology and Health Care' as

Healthcare is the treatment and prevention of illness that is delivered by professionals in medicine, dentistry, nursing, pharmacy and allied health.

Phelps (2002) pointed out that healthcare industry includes several social and political issues surrounding such as medical management of illness, reimbursement of health care costs and the collective state and range of health in a population. Krugman (2008) proposed that the delivery of modern health care depends on an expanding group of trained professionals coming together as an interdisciplinary team. Similar and related definitions for healthcare can be referred in Arrow (1963), William (1987) and USDL (2007) etc.

The modern healthcare industry incorporates several sectors that are dedicated to providing health care services and products. According to industry and market classifications, such as the Global Industry Classification Standard and the Industry Classification Benchmark, the health-care industry includes health care equipment and services as well as pharmaceuticals, biotechnology and life sciences. The particular sectors associated with these groups are: biotechnology, diagnostic substances, drug delivery, drug manufacturers, hospitals, medical equipment and instruments, diagnostic laboratories, nursing homes, providers of health care plans and home health care.

Healthcare systems depend largely on health policies that are carried out by countries. For instance, as mentioned in Chapter 1, Chinese healthcare system is a three-tier system and community healthcare is emphasized in this system. The aim of this system is to meet the health care needs of such a large underserved population.

3. Design

The foundations for 'a science of design', was laid in 1969, by Herbert Simon (Simon, 1969), an American economist, psychologist and Nobel Laureate. Simon defined the domain as '*a body of intellectually though, analytic, partly formalizable, partly empirical, teachable doctrine about the design process*.' The design domain also differentiated itself as a subject on its own right but different from sciences or humanities by arguments such as '*The natural sciences are concerned with how things are …. design, on the other hand, is concerned with how things ought to be*' (Simon, 1969) and '*there exists a designedly way of thinking and communicating that is both different from scientific and scholarly ways of thinking and communicating, and as powerful as scientific and scholarly methods of enquiry when applied to its own kinds of problems*' (Archer, 1979)

In this paper, the term 'design' is considered as 'Product/service design', which is defined as 'creation of products/services with new or different characteristics that offer new or additional benefits to the customer'(businessdirectory). It may involve modification of an existing product or its presentation, or formulation of an entirely new product/service that satisfies a newly defined customer want or market niche. Furthermore, a new theory called

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'New Product Development (NPD)' is also relevant with 'design' in this thesis, which is normally defined as (Ulrich, 2008)

The term is used to describe the complete process of bringing a new product or service to market.

4. Rural China

The last term to be defined is 'rural China', which mean Chinese patients who live in rural regions. Compared with urban people, rural patients have requirements of such as personal care (chronic diseases, communicable diseases et al), involvement of medical insurance and medical information management. The reason is closely related to the shortage of medical resources in rural areas.

As a target group, 'rural China' has several obvious features. For instance, their incomes are usually limited and considerably unsteady; besides health problems, they are often suffering from other problems like lacking energy and drinking water.

There is no specific theory about 'rural China'. However, a general theory called 'Base of the Pyramid' (BoP) can be adopted into 'Rural China'.

The initial reminiscence about BoP is from U.S. president Franklin D. Roosevelt in his April 7, 1932 radio address, The Forgotten Man, in which he said:

These unhappy times call for the building of plans that rest upon the forgotten, the unorganized but the indispensable units of economic power…that build from the bottom up and not from the top down that put their faith once more in the forgotten man at the bottom of the economic pyramid.

The more current usage of BoP was first defined in 1998 by Prahalad and Stuart(Prahalad and Hart, 2002), who defined 4 billion people living on an income less than US$3 per day and 1 billion living less than even US$1 per day as "Base-of-the-Pyramid" (BoP). Other definitions are also proposed all over the world, for instance, London (2006) defined BoP as "*an informal economic body who live outside mainstream markets*", it does not simply statistic BoP population through calculating incomes.

The initial commercial idea about Base of the Pyramid (BoP) is from Prahalad's book 'The Fortune at the Bottom of the Pyramid' (Prahalad and Hart, 2002), in which he proposed a framework for the active engagement of the private sector and suggests a basis for a profitable win-win engagement. He argued that all that is stopping business from designing products and services to meet the needs of the world's poor, and then efficiently manufacturing and distributing them is human ingenuity - innovation.

Purpose

Currently, Substantial studies and publications are relevant to ICT, healthcare, design and rural China. Most issues about them, in which authors claim to have theoretical foundation, were either based on theories from outside of design (e.g. Information processing,

management science) or on theories that can only be applied to limited aspects of the subject of design study (e.g. software development, architecture design). However, there is rarely literature that directly contributes ICT healthcare design in rural China.

Therefore the aim of this paper is to provide an overview of literature relevant to ICT healthcare design in rural China (IHDRC) so that ideas and indications for the topic can be inducted and conducted in the future studies.

Three literature domains

Past studies on 'design composition' propose three basic elements in the design process: users, designers and the (to be designed) product/service. (Paul and Betiz, 1978; Rozenburg and Eekels,1995) They are also effective in IHDRC. Thus the choice of literature domains is based on these three basic elements. In this paper three literature domains were chosen: Design for Base of the Pyramid, User Centered Design and ICT healthcare design. Above three domains completely target these three basic elements. Furthermore, more or less additional literature will also be referred. For example, Freudenthal et al (2010) pointed out that medical design domain was already beyond traditional User Centered Design and thereby she proposed a new ambitious approach combining human factors and design thinking. UNDP (2008) warned that BoP design domain is a policy altering issue rather than simply market-oriented. These publications the three adapt three traditional literature domains are helpful as well.

Design for Base of the Pyramid

Design for Base of the Pyramid (DfBoP) is a concept proposed by academic design schools after Prahald's BoP market theory in which he defines 4 billion people living on an income less than US$3 per day and 1 billion living less than even US$1 per day as "Base-of-the-Pyramid" (BoP)(Prahalad, 2002). As a target group, 'rural China' has several obvious features that are similar with BoP. For instance, their incomes are usually limited and considerably unsteady; besides health problems, they are often suffered from other problems like lacking energy and drinking water.

One example about Design for Base of the Pyramid is from the Illinois Institute of Technology's Institute of Design. Initiated in 2003, this project explored 'Human-centered design strategies and concepts for new products, services and businesses capable of generating sustainable economic improvement in the lives of people living in the vast base of the global economic pyramid.' This project began with an exploratory phase (Phase I), conducted in the summer of 2003 in Chicago and in three cities in India and then several BoP design cases were carried out to explore design knowledge.

The similar effort is from Faculty of Industrial Design Engineering, Delft University of Technology (IDE/TuDelft). Several DfBoP cases have been set up starting from 2003, such as "Solar Lamp for Africa" or "Adoptive woodstove for India". (Kandachar et al, 2009) In the past eight years, based on about seventy student BoP design projects, some initial results have been suggested in IDE/TuDelft through observation from cases, for instance:

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Kandachar and Halme (2008) found that all cases started by studying the needs of the users about BoP product and innovations. They observed that several design methodological innovations are taking place that need to be considered for an effective approach to serve the unmet needs of the BoP-community. These innovations include: on user side ethnographic tools, cultural probes, business innovations such as hybrid business models, corporate responsibility, technological innovations like disruptive innovations, open source designs, etc. Other innovations at the entrepreneurial side such as microfinance, social entrepreneurship need to be considered as well.

Several researchers (Penchansky, 1981; Carayannis et al, 2005; Braimah, 2010; Diehl 2008) defined principles of DfBoP in terms of sustainability: "DfBoP means Integral Product Development for the BoP which includes four characteristics: (a) Acceptability-sustainability user, profit and planet, (b) Awareness- user context research, (c) Availability-new technologies and innovations, (d) Affordability- business development. (More information is available on website: www.io.tudelft.nl/bop)

Recently, the term 'Design for Base of the Pyramid' also appeared in worldwide organizations such as United Nation Development Program (UNDP). In the report from UNDP (2008), the definition of 'DfBoP' includes product design, business design and social design.

The theoretical trial of 'DfBoP' can be tackled approximately in three fields of knowledge: BoP theory, social impact theory and innovation management theory. Figure 1 provides an overview of literature. For instance, in BoP theories, Prahalad (Prahalad and Hart, 2002) pointed out 12 principles about market emerge and innovation, Christensen et al(2006) said disruptive innovation (an innovation that disrupts an existing market) from BoP users could be driven, while Hart (Hart and Christensen 2002) gave a protocol to drive the innovations. In social impact aspect, Arnould (Arnould and Mohr, 2005) proposed that BoP local culture (social-cultural impact) will affect design activities and results a lot. and in innovation management aspect, Barczak et al (2006 and 2009) provided ideas about innovative investigations of new product development, Bart (2002 and 2007) said that content exploration and management will affect product design process, and Swan (2005) gave suggestions on innovation for robust product development.

Until now, all three knowledge fields are still under development. Some market - successful cases in the three intersecting fields were piloted, like shampoo case (Uniliver designed small packaging for BoP countries (Prahalad and Hart, 2002)) or mobile phone case. (Nokia developed simplified function and cheap mobile phones for BoP countries (Kandachar and Halme, 2008)). However investigations in the cross fields are not yet mature.

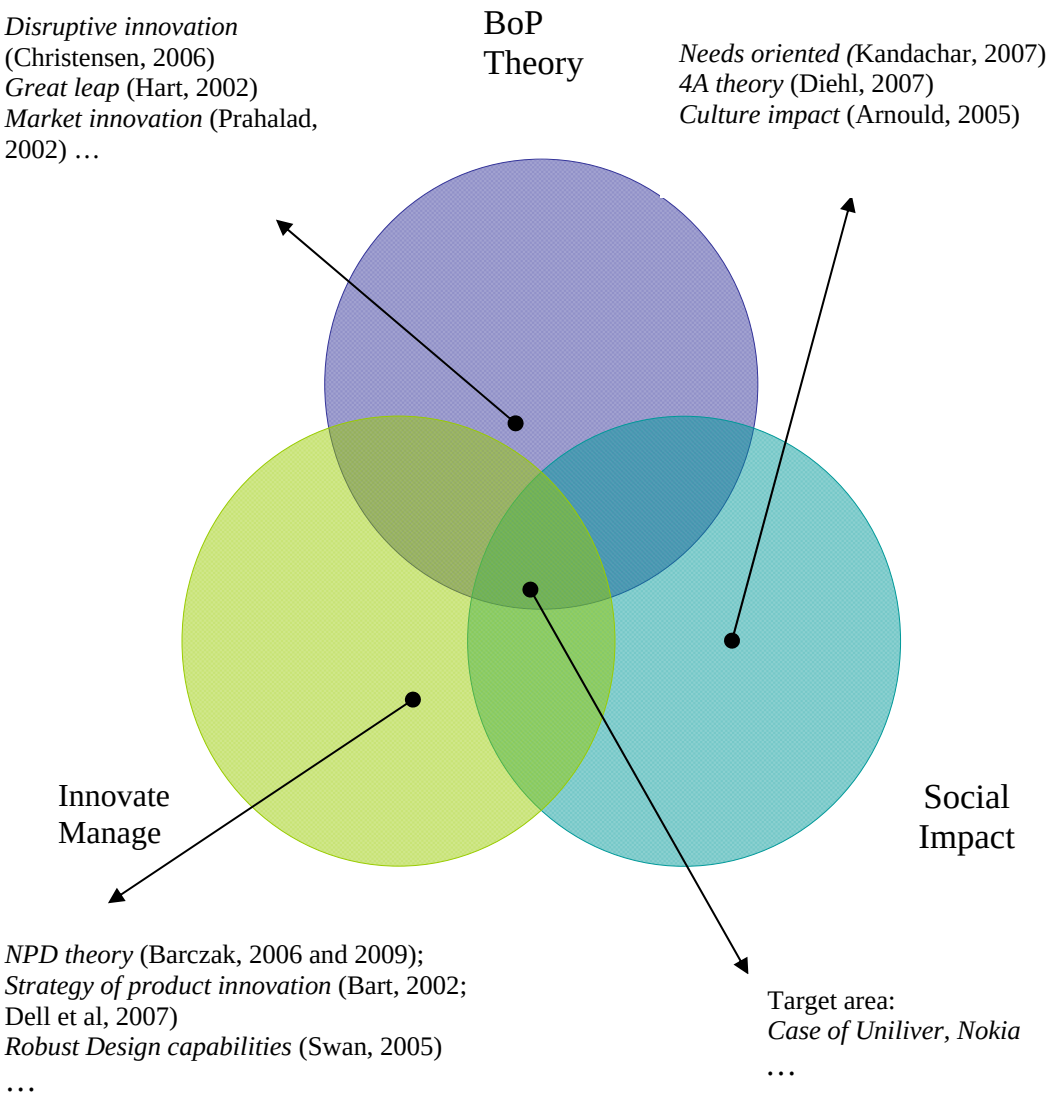

Figure 1: Literature fields relevant to Design for Base of the Pyramid (Christensen, 2006; Prahalad, 2002, etc.)

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User Centered Design

User Centered

Design (UCD) is a frequently used design philosophy and process in which users' needs and wants are the focus in the early stage of a design project. (Norman and Draper, 1986) In the past decades, UCD was widely implemented into ICT applications such as interface development in software systems (Troyer and Leune, 1998; Vredenburg et al, 2002; Randay et al, 2002), situation awareness (Endsley et al, 2003), virtual environment (Hix et al, 1999), and cross-language information. (Daniela et al, 2004).

In this decade, UCD is recognized as a core approach in design issues. Daniela et al (2004) declared that UCD methods are effective to achieve designing pleasurable products. As one of the leading lights in the field of cognitive ergonomics, he looked at UCD approaches that assume that if a task can be accomplished with a reasonable degree of efficiency and within acceptable levels of comfort, then the product can be seen as fitting to the user.

Generally, UCD are competitive in complex design situations (King etc, 1989) such as ICT applications (Bødker et al,2000) and healthcare applications. (Westerlund, 2003) For example, Mark and Stephen (Mark and Stephen, 1990) presented a run-time conflict resolution UCD model for ICT applications among designers, market experts and manufacturing experts; Rossenau et al (1988) argued that cooperation between designers and users in ICT applications plays an important role in early stage of design process, including idea generation. In her viewpoints, users were considered as not only information providers but also information collectors; Hong (Hong et al, 2002) proposed a multi-agent UCD design model for healthcare applications, which might solve communication problems among different design teams; Healthcare applications between users and designers were also studied by Visser and she proposed that cooperation-phenomenon exists in the whole context mapping (a procedure for conducting contextual research with users, where tacit knowledge is gained about the context of use of products) process including preparation, sensitization, session, analysis, sharing and conceptualization. (Visser, 2009)

The education and research profiles in IDE/TuDelft haven been largely built on UCD in the past twenty years. An education course (amongst others) for all bachelors and masters: 'Delft Design Methodology' is generated from UCD approaches and models. In other words, UCD influenced designers and researchers' design thinking in IDE/TuDelft including the author.

In practice, there are three frequently used UCD models: cooperative design model, participatory design model and Contextual design.

1. Cooperative design

Cooperative design, as mentioned and developed in Scandinavia in 1970s (Greenbaum and Kyng, 1991; Mogensen and Trigg, 1992), stresses the importance of creative involvement of potential end users in design process in general.(Bcdker etc, 1993) In the product design domain, cooperative design has at least two different definitions:

1) The interaction between the designer and the user is essential

According to the IDSA (Industrial Designers Society of America), "Industrial Design (ID) is the professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer". One responsibility of product designer is to satisfy users. It means the direct interaction between the designer and the user is necessary in the design process. There are a lot of tools and techniques such as interview, video, questionnaire to facilitate this interaction.

Cooperative design is also named as “the designer as user” by Rossen (Rossen etc, 1985). She points out cooperation between designers and users plays an important role in the early stage of design process like idea generation. In her viewpoints, users are considered as not only information providers but also information collectors. The cooperation between users and designers is also studied by Visser and she proposes that cooperation-phenomenon exists in the whole context mapping process including preparation, sensitization, session, analysis, sharing and conceptualization. (Visser, 2009)

2) The design environment of the project is cooperative

As a creative activity with evolutionary nature, design is a team effort and in which groups of designers with different intent and background knowledge work together. Close collaboration among them will accelerate the product development by shortening the development cycle, improving the product quality and reducing investment. For example, design of a lamp may require experts on properties of materials, ease of manufacturability, kinds of available energy, potential markets for the lamp, and so on.

Because different knowledge is needed in one design project, cooperative environment has been considered to achieve knowledge interaction in many studies. Mark and Stephen (Mark and Stephen, 1990) gave a run-time conflict resolution cooperative model among designers, market experts and manufacturing experts. The design environment within and outside team was mentioned. Hong (Hong etc, 2002) proposed a multi-agent cooperative design environment, which might solve communication problems among different design teams. With the product global commercial, cooperative environment becomes more and more important in design projects. Cooperative design (sometimes called ‘Co-design) is often used for complex design situation (King etc, 1989) such as applications of Information and Communication technology (ICT). (Bødker etc, 2000)

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2. Participatory design

Participatory design is another frequently used industrial design approach that attempts to actively involve the end users in the design process to help ensure that the product designed meets their needs and is usable. (Schuler and Namioka, 1997) In this definition, potentially end-users will be invited to participate in several stages of an innovation process: they participate during the initial exploration and problem definition both to help define the problem and to focus ideas for solution, and during development. They help evaluate proposed solutions as well.

Participatory design can be seen as a move of users into the world of designers and researchers according to demand of involve community opinions in major decision-making (Wheeler, 2004). Muller and Kuhn (Muller and Kuhn, 1993) had concluded many participatory designs related methods and tools into one graph (figure 2): the X-axis is the design process from early stage to late stage and the Y- axis is the participatory level of users.

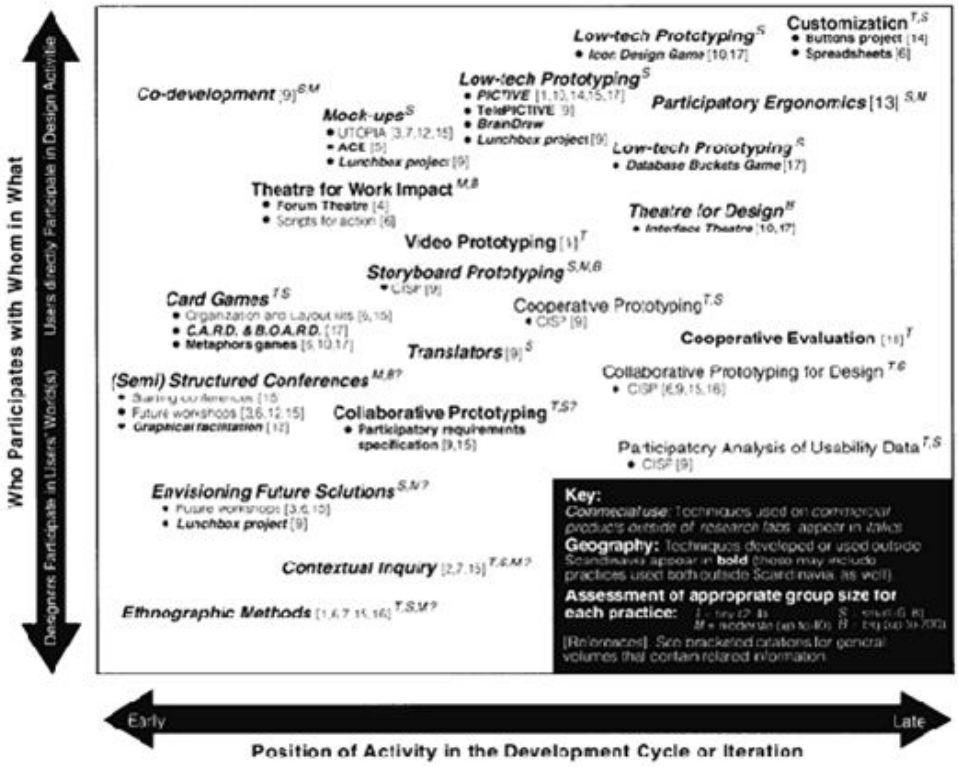

Figure 2: Participatory design approaches (Muller and Kuhn 1993)

There are three kinds of customer participatory approaches (Matti Kaulio, 1998) in product development: Design for customer, Design with customer and Design by customer. The

customer involvement activities could be located in figure 3 in terms of different phase of design process.

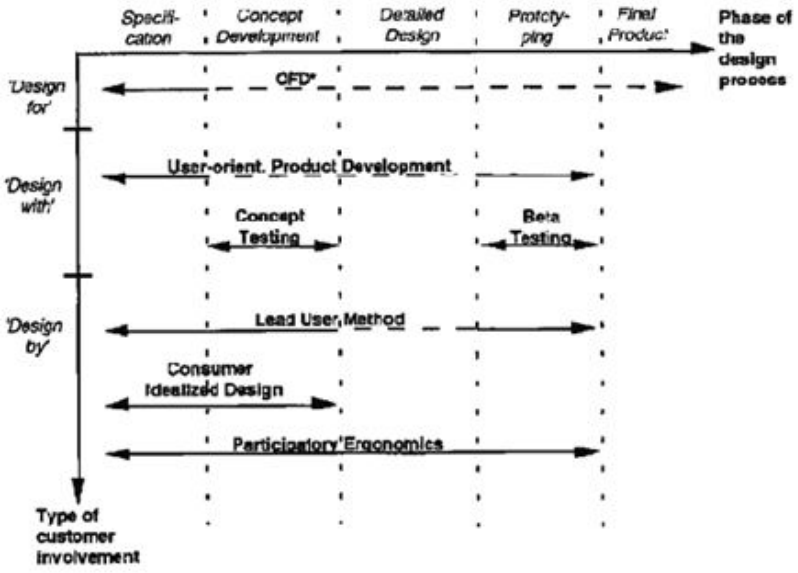

Figure 3: Customer involvement approaches (Matti Kaulio, 1998)

3. Contextual design

Contextual design is a UCD process developed by Beyer and Holtzblatt (Beyer and Holzblatt, 1998). It indicates that user context research may be the start of the design process and incorporates ethnographic methods for gathering data relevant to the product such as field studies, rationalizing workflows, system and designing human-computer interfaces. Contextual design has been developing in recent years and has been recognized as one important approach in product development. For instance, the ViP process (Hekkert and van Dijk, 2001) and Rapid Contextual Design process (Holtzblatt et al, 2005) are based on contextual design approach.

The Contextual Design process consists of the following top-level steps: Contextual inquiry, Work modeling, Consolidation, Work redesign, User Environment Design, Prototyping and Implementation (Beyer and Holzblatt, 1998) and several working models such as Flow model, Sequence model, Cultural model have been proposed within the framework. (Holtzblatt, 2001)

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Recently, other UCD approaches are also used in product development like Lead user approach (Christian and Cornelius, 2004) or Applied ethnography (Chambers, 2000).

ICT healthcare design

The third literature domain in this thesis is 'ICT healthcare design'. Studies in this domain have developed quickly in this century due to the increasing demands of ICT usage and healthcare requirements. For instance, Home healthcare is becoming popular in the USA - the biggest market for medical devices. Aging population growth and chronic diseases afflicting USA government require longer hospital stays (Engelhardt and Greenhalgh-Stanley, 2010). Longer hospital stays increase healthcare cost. Therefore, patients are shifting towards economical home care. In addition to higher costs, longer hospital queues force patients to seek home care. (De Rouck et al., 2008). Patients now express a need for greater participation and control in healthcare decision-making (Lemire et al., 2006). This need accelerates on increasing information access at home through different media like internet.

Different from other "normal" consumption products, supports are emphasized in ICT healthcare design. Supports here include physical infrastructure supports, social-technical supports, political supports etc. For example, a typical ICT healthcare product/service design involves various systems and networks: Besides users it needs administrators to maintain the whole system; it needs channels to transmit data; it needs standards which are regionally recognized by (local) governments and medical staffs and public health supports, like medical insurance should also be considered.

In general, investigations about ICT healthcare design can be divided into two categories:

1. ICT healthcare design methodology

There are hundreds or even thousands publications which are relevant to ICT healthcare design methodology in which various specific aspects have been highlighted. For instance, Haux et al (2010) emphasized five aspects about the Information Processing Methodology(IPM) in ICT healthcare design: (1) the main goal of expanding IPM/ICT should be to further improve quality of care, while maintaining reasonable costs; (2) with the support of modern IPM and ICT the boundaries between inpatient and outpatient care will fade away enabling a more efficient, patient-centered health care; (3) cooperation between health-care professionals will increase; there will be different ways of communication between them and with the patient, including modern ICT and the Internet; (4) society must be concerned with achieving equal opportunities in being informed about and in using new ICT; (5) misuse of data will remain a serious problem and can become an obstacle to progress. Berg et al (2003) proposed a socialtechnical view on the development of process-oriented ICT in health care in which he argued that modeling should not be conceived as the crucial first step in this design, but rather as an intervention in the organizational change-processes that constitute proper ICT development. Scandurra et al (2008) presented a new multi-disciplinary method for development of health information systems, which is from user needs to system specifications.

2. ICT healthcare design implementations and evaluations

Various publications focus on different aspects of implementation and evaluations for ICT healthcare design including economics, authority, and ethics and so on. For example, Vimarlund et al (2005) did economic analyses for ICT healthcare design. He declaimed that performing evaluations of ICT healthcare designs should be very specific about classic issues in economic analysis, such as defining alternatives, the basis for comparison, and combining different indicators into an overall evaluation. Sanderson (2007) provided his view about ICT healthcare design as a cognitive engineer in which he argued that promising, simulators have significant technical and operational limitations for ICT healthcare design, and they do not address important aspects of the sociotechnical systems context in which healthcare ICT will be embedded. Berler et al (2004) pointed out that the integration of information systems represents one of the most urgent priorities of a regional healthcare authority in order to meet its clinical, organizational and managerial needs.

Overview of knowledge gaps about ICT healthcare design in rural China

Past studies in the three domains suggest possible knowledge gaps about IHDRC. According to Bridge (2008), design constraints on ICT healthcare design in rural areas of developing countries distribute on the early stage of the design process, which is usually called 'understanding' stage of the design stage. Designers often meet problems about setting up a complete information category, collecting all kinds of sources and choosing suitable approaches in the design process. This opinion is also extended by other researchers. For instance, Prahalad (2002) and Hart (2007) emphasized that rural user can be considered as the potentially consumer to be emerged in ICT healthcare but entrepreneurs is necessary; Kandachar (2007, 2009) argued that the need of rural user (human) should be considered as the start of ICT healthcare design case but the design approach need innovations; A number of publications (Dibsdall et al, 2007; Carayannis et al, 2005; Braimah, 2010; Diehl 2008) proposed that 4A (Accessibility, Availability, Awareness and Affordability) is the principle for product development and innovation in rural areas. Figure 4 is an overview about possible important knowledge gaps in IHDRC, which is composed of four main categories.

In the past several decades there has been a growing awareness of the importance of women's empowerment in overall development. It is not sufficient to consider only economic growth, but rather we must also look to human development (and specifically that of women) when observing progress in any country. This can be difficult to define and measure, as one must be sensitive to cultural and historical differences as well as overall standards of living for a society. However, even considering these differences, it is essential that women be equal partners in the development process for their nations to truly be successful on both the international and domestic fronts.

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In this paper, the author explores the evolution of today's focus on women and what important patterns of development exist when it comes to women and girls. These fall mainly into four categories—education, health and family, economics and labor, and political activism and representation.

This discussion leads to a regional overview of Latin America and an examination of how women stand in each of these categories, baring in mind important cultural roles that still remain. Building on this, the author moves to an in-depth comparison of two countries considered to be on opposite ends of the development spectrum: Brazil, long considered the emerging economy of the region, and Bolivia, a nation that has long suffered from some of the most severe poverty in Latin America. The author explores the general state of women's empowerment in each country by category and questions how they compare. The author concludes that based on these findings Brazil is not as far in advance of Bolivia as one would think, but that there has been significant development in both countries as well as continuing room for major growth.

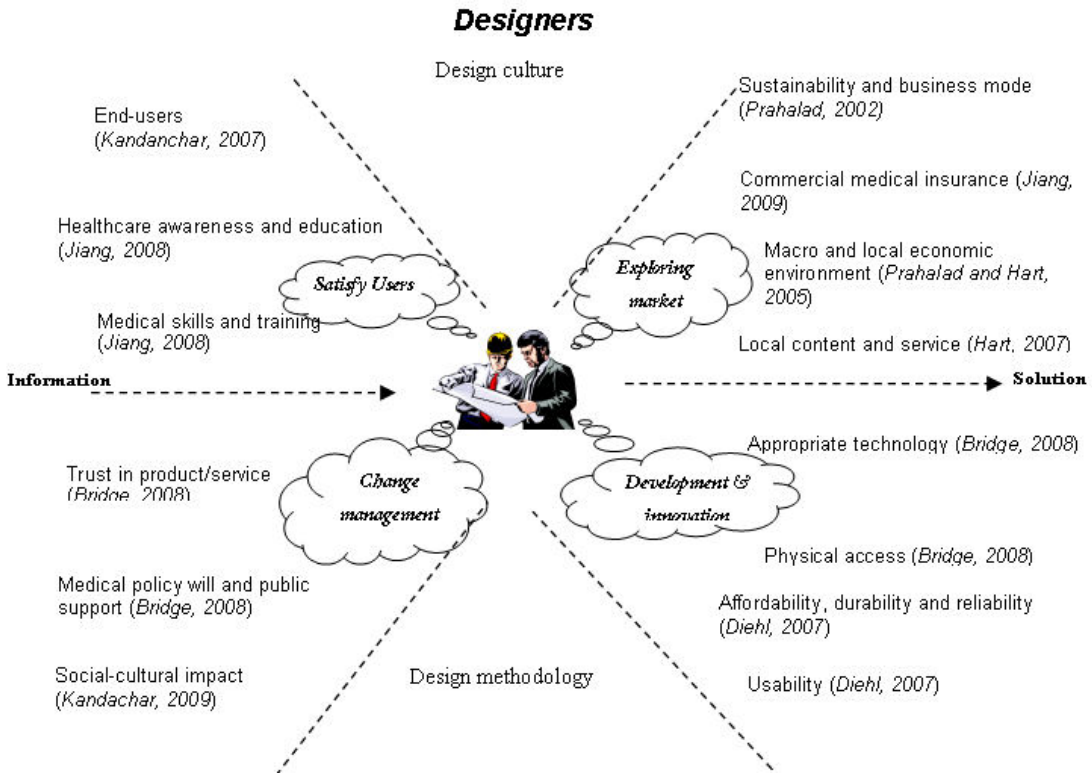

Figure 4: An overview of knowledge gaps about ICT healthcare in rural China (Jiang et al, 2009)

- Satisfying users: Contents of this category include solving patients' medical needs (Kandachar, 2007), improving healthcare awareness of patients (Bridge, 2008) and enriching skills for medical staff (Bridge, 2008).
- Emerging markets: Contents of this category include providing sustainability and business model (Prahalad, 2002), building up local content and service (Hart, 2007), adopting Macro and local economic environment (Prahalad and Hart, 2005) and providing commercial medical insurance (Bridge, 2008)
- Product development and innovation: Contents of this category include keeping design usability (Dihel, 2008), keeping design affordability, durability and reliability (Dihel, 2008), using appropriate technology (Bridge, 2008) and adapting physical access (Bridge, 2008)
- Managing changes: this category is to keep changes under control in the design process. For example, designers should consider social-cultural impact (Kandachar, 2009), build up trust in product/service from users (Bridge, 2008) and get medical policy will and supports from outside environments. (Bridge, 2008)

Existing design models relevant to ICT healthcare design in rural China

Moreover, literature provides not only knowledge gaps, but also possible solutions to part of them. In this section we will introduce some models that might be helpful for ICT healthcare design in rural China.

Design models for DfBoP domain

Models dealing with the DfBoP domain are relevant with three knowledge fields: BoP theory, innovation management and social impact study. For example, user information exchange model according to Lundvall (1985), can be used for designers to manage innovations. It pointed out several important aspects about information exchange amongst users, designers and companies; Gupta et al (1986) proposed a model in which a willing of emerging market is usually a start of product innovation. Nicosia's model (1966) simplified the customers' decisions. Here we would like to introduce two models that are frequently used.

The Base of the Pyramid Model 2.0

The BoP Model 2.0(Simanis et al, 2008) is a completely BoP model that emphasizes social impact aspects. It was established in 2004 and developed into the second version in 2008. It consists of three interdependent activities: (1) the selection of appropriate BoP project site(s); (2) the formation and training of a multidisciplinary corporate "field" team; and (3) the selection of local community partners. A fourth core activity is the creation of an enabling environment (R&D White Space) within the corporation that supports experimentation outside of the current business model and business development process. Depending on the company's experience in the Base of the Pyramid, and the extent of its

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social networks in the region of interest, the length of time needed to complete pre-field activities will range from two to four months. Figure 5 illustrates this model. Furthermore, a concrete protocol called "The Base of the Pyramid protocol 2.0" was developed after field study in rural India.

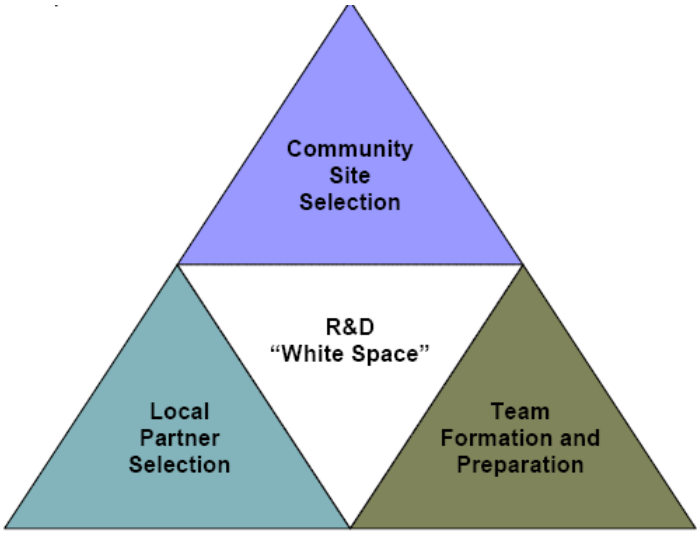

Figure 5: The Base of the Pyramid Model 2.0 (Simanis et al, 2008)

Knowledge chain model: activities for competitiveness

The second design model we introduce is a knowledge chain model, the so called 'competitiveness model' (Holsapple et al, 2001). This knowledge chain model, which emphasize innovation management in BoP countries, is based on a descriptive knowledge management (KM) framework developed via a Delphi-study involving an international panel of prominent KM practitioners and academicians (Holsapple & Joshi, 2000). This framework identifies five major knowledge manipulation activities that occur in various patterns within KM episodes. It also identifies four major managerial influences on the conduct of knowledge management. Respectively, these form the five primary and four secondary KM activities in the knowledge chain model (Holsapple & Joshi, 2000). As Figure 6 suggests, these activities yield organizational learning (i.e. changes in an organization's state of knowledge) and projections (i.e. organizational resources being released into the environment). A basic premise of the knowledge chain model is that how well an organization learns and how well it projects are important determinants of the organization's viability and success in a competitive environment.

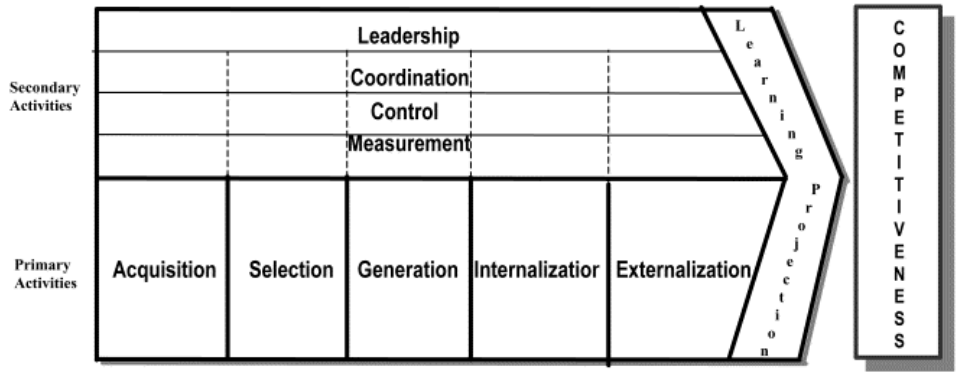

Figure 6: The knowledge chain model (Holsapple etc, 2001)

Design models for UCD domain

A few models about User Centered Design domain such as information process (specialized in product innovation process) can be tracked in literatures, such as Pauhl and Betiz (1980), Roozenburg and Eekels (1995), Hekkert and van Dijk (2001) etc. Roozenburg and Eekels (1995) pointed out basic workflow on information process in product innovation development; Hekkert and van Dijk (2001) said "Product innovation process is a circle from past product to a future product, which comes through an interaction process between product and context surrounding product" and ViP model (Muller, 2001) is very useful for design for sustainability. These design models emphasized designers as a processor of data and showed that the process of design is influenced by the cognitive limitations and capabilities of designers. Here we would like to introduce one design model which can be referred in this study.

Sander's co-creation model

Sander's co-creation model (Sanders, 2009) is an experience model in product development to describe different levels of design (research) thinking. There are five layers in this model as Figure 7:

- Layer A: Culture. This layer describes the customs, arts, social institutions and achievements of a nation, people or other special groups; a set of learned beliefs, values and behaviors shared by a group of people.
- Layer B: Mindset. This layer describes the established set of attitudes held by designers; designers' frame of references.
- Layer C: Methodologies. This layer describes a system of methods used I a particular area of study or activity.

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- Layer D: Methods. This layer describes a particular form of procedure for accomplishing or approaching something, especially a systematic or established one.
- Layer E: Tools and technologies. This layer describes a device or implement used to carry out a particular function and a way of carrying out a particular task.

Figure 7: Sander's co-creation model in product development for designers (Sanders, 2009)

Design models for ICT healthcare

Design models for ICT healthcare design domains are highlighted in publications. For example, Zimmermann and Vanderheiden (2008) proposed a 4-step model for the development of software application development that is closely aligned with best practices of software engineering. Berg et al (2010) proposed sociotechnical approaches to increase the understanding of how ICT applications are developed, introduced and become a part of social practices. Based on several models, Aarts et al (1998) described a model about ICT change with healthcare requirements.

The model of ICT change with healthcare requirements

The last model we refer to is a model about ICT change with healthcare requirements. (Aarts et al, 1998)(Figure 8) This model consists of eight stages or domains that were considered essential when implementing a system in a healthcare organization.

Stage 1: 'Assessing and understanding what-and for what key reasons-activities occur at each level'. This stage requires that the implementer or researcher understand the nature and content of clinical work and its context, especially how the context (legislation, rules, cultural values, etc.) might determine clinical work.

Stage 2: 'Assessing and understanding the context and identifying consequences for clinical work and imperatives for change'. Important in this stage is the fact that clinical work is very much determined by external factors such as political goals for the health care system, local situations, economic circumstances, cultural values and personal motivations and that it is important to identify those factors which are imperatives for change.

Stage 3: 'Selecting and prioritizing opportunities, problems, imperatives and requirements for change'. There are many factors that may prompt change, however, it is important to select and prioritize those factors that must matter in the situation of a particular system. Listening is very important, but informed decision making and organizing support are the most important features of this stage

Stage 4: 'Knowing of appropriate technological developments and relating them to information requirements; knows of opportunities and imperatives for change'. Sufficient knowledge of information and communication technologies is required.

Stage 5: 'Creating an information and technology strategy and financial plan'. This stage is either seen as so obvious that it is often not considered in health care organizations or it is seen as a mechanistic and low level task.

Stage 6: 'Involving, informing, persuading and preparing for these technologies and other changes' This stage calls for a whole array of social and organizational skills, including inter-personal skills and as well as technical credibility.

Stage 7: 'Planning and introducing new technologies with other changes'. This stage requires what are often seen as a different set of more formal, project and program management skills, techniques and behaviors.

Stage 8: 'Evaluating, reviewing and assessing the impact and valuing it'. Every implementation of change requires that its impact will be evaluated, reviewed and assessed using formal qualitative and quantitative methods but also valued to enable judgments are important for future improvements and changes, not least to adapt their organization's systems as installed.

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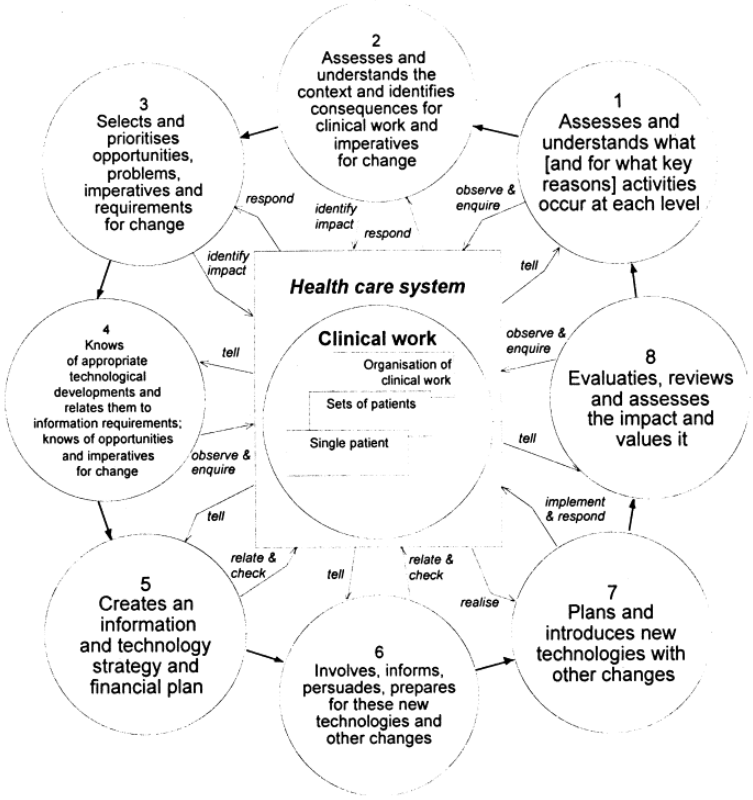

Figure 8: The model of ICT change with healthcare requirements (Aarts et al, 1998)

Discussion

Limitations of existing design models

These design models(such as four chosen models) more or less covered parts of gaps but missed other parts.(see table 1) For example, Sanders'co-creation model (2009) specialized in providing approaches to transfer problems into solutions such as experience models, participatory modeling but it lacked inputs for other parts such as features of product innovation; The BoP Model 2.0(Simanis et al, 2008) proposed some helpful information about user innovations, such as it suggested to hire local partners to decrease the influence of cultural difference but it lacked inputs for product innovation; the knowledge chain model (Holsapple et al, 2001) proposed a companies' involvement approach but it lacked inputs for environment and user innovations; and the model of ICT change with healthcare requirements (Aarts et al, 1998) proposed a 8 step approach and limited information about ICT design in step 2, 3, 4, and 7 but it lacked inputs for product innovation.

Table 1: The matrix about the cover of referred models for knowledge gaps

Knowledge gaps	**Co-Creation model**	**Knowledge chain model**	**The BoP model**	**ICT healthcare model**
User information	Observation, Personas and scenarios to explore information	Knowledge generation model	Building Deep Dialogue	Understand contexts in Stage 2
Healthcare awareness and education	X	X	X	Plans and introduction of technologies in stage 7
Medical skills and training	X	X	X	Select and Prosperity requirement for change in stage 3
Local content and service	X	Knowledge internalization model	Building Shared Commitment	Access the context in stage 2
Macro and local economic environment	X	Knowledge externalization model	Collective Entrepreneurship Development	X
Sustainability and business mode	Transition Planning	Knowledge coordination model	Building The Market Base	Create a finial plan in Stage 5
Usability	Usability test	X	X	Informs of ICT technologies in stage 6
Affordability, durability and reliability	X	Knowledge control model	X	X
Trust in product/service	X	Knowledge leadership model	X	Introduction of technologies in stage

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Social-cultural impact	X	Knowledge measurement model	New Capability Development	Identify impact in stage 2 and measure impact in stage 8
Design Methodology Adaption	X	Systematic design thinking	Co-Creation Logic	X
User Central Design applications	Experience models, Experience timelines, Participatory modeling,	X	Field study	Tell, Observe and enquire
Design guide and tool	Three-dimensional toolkits	Delphi Study	The Base of the Pyramid Protocol 2.0	X
Strength of each model	User Centered design and its application in healthcare environment	Company oriented approach	Bop Concentrated	ICT healthcare model
Weakness of each model	Not ICT involvement, Not business-related	Not ICT healthcare involvement, Not Design oriented	Not Design oriented and not ICT healthcare specialized	Rare design factors, not business extension and BoP specialization

It means that a new framework based on integrating these four models (and inputs from other investigations) is needed for ICT healthcare design in rural China.

New investigations in three areas

Based on literature review, the author proposes three investigation areas to be developed. The outputs of these three areas may provide additional inputs to generate the new framework. They are described as follows:

1. Design culture exploration to overcome cultural difference between designers and users which influence IHDRC
2. Human factors' exploration to find out those important human factors in IHDRC

3. Design methodology exploration to adopting an existing approach to transfer problems to solutions in IHDRC

1. Design culture

According to Albrecht et al (2000), design culture generally presents cutting-edge work in architecture, landscape architecture, urban design, theatrical design, fashion, typography, film graphics, products, and new media. Usually this refers to the link between designers from culture A to users in culture B. From designers' side, cultural difference might result in different design decisions and actions in one project. A deep understanding about the influence of design culture in IHDRC will help designers to overcome possible design problems such as social-cultural impact and trust of product/service etc.

The target group of this research, as illustrated in Figure 9, is the influence of culture on product and services for rural china. The influence is expected to be coming from two sides: the culture of the designer (Culture A) and the culture of the user (Culture B). In the issue of culture A, research questions for 'What cultural factors are and how can they influence product and service design?' need be explored.

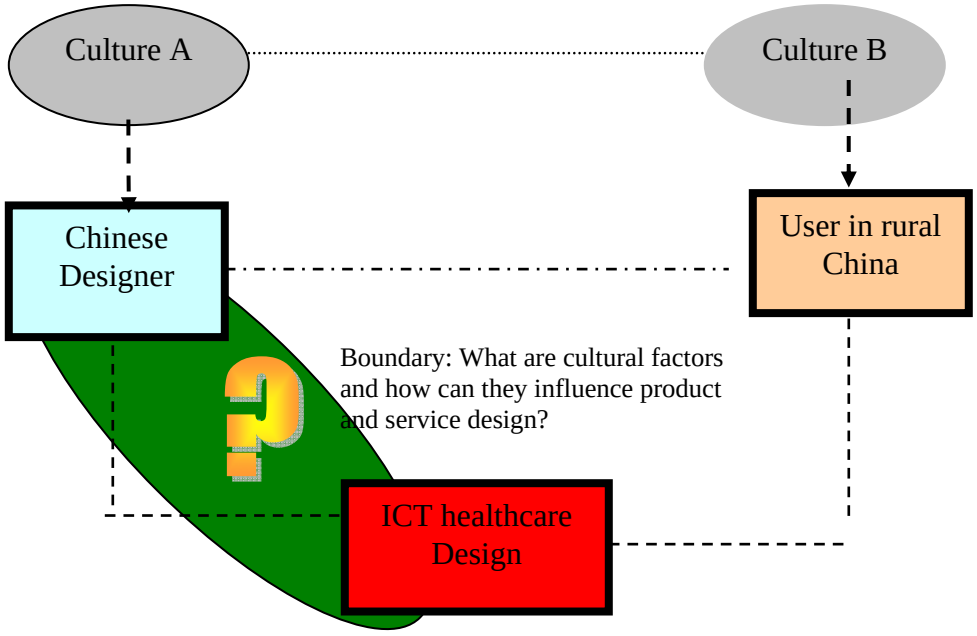

Figure 8 Area of investigation in design culture

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2. Human factors

The presumption of influence of human factors generally occurs when various types of committed or omitted human actions appear. The term 'human factor' usually applies to the science of understanding the properties of human capability, which is applied to the design, development and deployment of systems and services. Thus, this term is often well practiced as a multidisciplinary field incorporating contributions from psychology, engineering, industrial design, statistics, operations research and anthropometry.

However, in general cognitive ergonomics and structured information design in the medical domain is scattered, immature and often even totally lacking. Introducing methods from other domains (e.g., usability design for consumers or information design from aviation) can often not be conducted straight forward, because the context in which the homecare systems are being used and being developed is hardly comparable to the established ergonomic areas. For example, in the case of rehabilitation after heart surgeons, the target is to monitor the electrocardiogram and stabilize the instable biological signals of the patients, which is by natural highly unpredictable. This needs to be done by combining different technologies such as biological detection, signal process and wireless transmission. Each technology significantly has its own protocols, which are influenced by the culture and frame from different medical professionals by whom these technologies are operated.

Therefore, human factors for IHDRC need be explored as another possible investigation area.

3. Design methodology

This area refers to feasible design methodologies which can be adopted into IHDRC. Each institute/organization has its own design methodology for ICT healthcare and it may work in IHDRC or not. However, most approaches are product-oriented or technology-oriented methodologies rather than User Centered Design (UCD) methodologies. Therefore in this area one possibility is to choose one UCD approach (from industrial design issues) and adopt it into IHDRC.

Conclusion

This paper dwells on the background of ICT, healthcare, design and rural China (IHDRC), and reviewed literature that is relevant to this topic. Three literature domains were introduced in detail: Design for Base of the Pyramid, User Centered Design and ICT healthcare design. This paper also introduces several theoretical design models from those three domains. Subsequently four design models have been chosen for further study: Sander's model, Knowledge chain model, BoP model and ICT healthcare model. However, each model cannot bridge all knowledge gaps fully. It means a new model, based on exiting literature needs to be developed in the future.

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