Conditions for Implementing Innovating Telemedicine Procedures after Hip Arthroplasty

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Abstract. Telemedicine technology offers a wide range of possibilities for improving various forms of healthcare services. These technologies can support and economize healthcare service processes including medical consultations, preparation for medical treatment and in the post-operative period. The increasing number of older people in developed countries increases the importance of telemedicine as a way to economize the care of the elderly. Domestic healthcare is one such opportunity. This study focuses on the use of this technology as a networking achievement demanding integrated relationships and purposeful interaction to implement and use this technology including focus on use of domestic healthcare of elderly patients after total hip arthroplasty in Poland. This network of actors consists of importantly interaction between patients, healthcare service providers and technology providers. A combination of telematics technology, services theory and contingency theory creates a distinct network approach to understanding domestic healthcare as a particular form of service process provision implying development of the exchange economy to support the services production economy. The aim of the article is to analyze the conditions for innovative telemedicine procedures implementing after total hip arthroplasty. Due to the conducted considerations, a set of fundamental solutions in regards to network implementation and application in home healthcare of Polish elderly patients after total hip arthroplasty will be developed. Conclusions will also concern the potential market of telemedicine solutions for patients after hip arthroplasty in Poland. Attention will also be paid to restrictions on the implementation of new technologies and ways to overcome them.

Keywords: healthcare service process, telemedicine procedures, telemedicine technology, total hip arthroplasty, value of telemedicine market

1 Introduction

Domestic healthcare plays an important role for the use of telemedicine technology and can be supported with various forms of healthcare services. In 2050 every third person in Europe will have more than 60 years old and providing medical care for all those persons will not be possible. Due to lack of medical staff and emigration the number of

medical specialists in Poland is very small. Technology can support older in some procedures at home without a need to visit medical professionals personally. These are the main reasons to use telemedicine solutions. The aim of the article is analyses of conditions for implementing innovating telemedicine procedures after hip arthroplasty. Research is conducted within the EU-financed InterDoktorMen project.

2 Conditions for implementing innovating telemedicine procedures

To study the complexities of on innovating telemedicine procedures after hip arthroplasty we apply, as suggested by Engelseth and Kritchanchai (2018), a combining of contingency theory with ecosystems thinking. Firstly, contingency theory (1967) is applied as our fundamental theoretical approach. Ecosystems thinking refines this approach. Contingency theory implies a process approach to in this case a service production. A fundamental management stance in contingency theory is that there is no best way to organize a corporation (Lawrence and Lorsch 1967). This approach encompasses focus on resource use and transformation; the dynamics of innovating telemedicine procedures after hip arthroplasty. This implies that processes are viewed as fundamentally speaking, environmentally contingent. Conceptually, "context" is this approach the part of the environment direct interaction between the sequences of healthcare service providers. This again implies that "environment" forces not necessarily interacting, but still impacting on healthcare services in a more one-way manner. Figure 3 developed by Engelseth and Kritchanchai (2018) describes this approach:

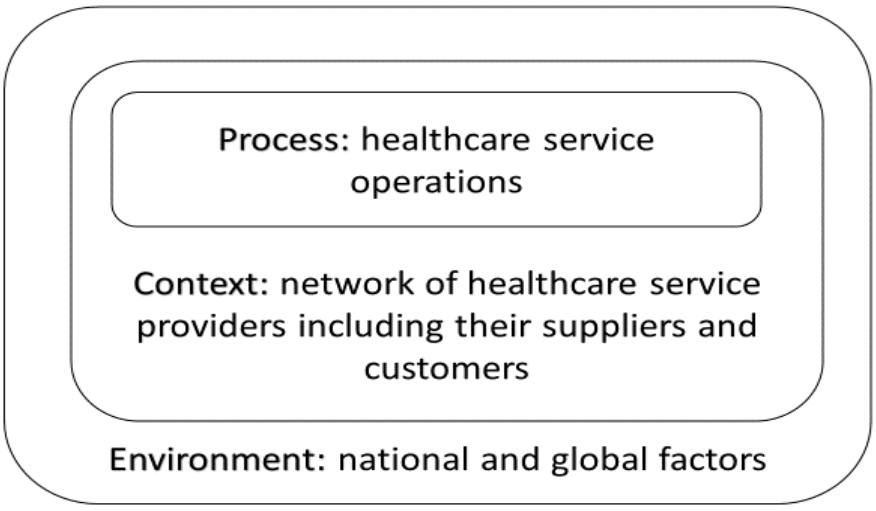

Figure 1. The healthcare service process as embedded unit of analysis (Engelseth and Kritchanchai, 2018).

Process management involves in our case study the actual flow telemedicine procedures after hip arthroplasty. This involves aspect importantly two aspects: (1) the combining of more or less heterogeneous resources to achieve complementarity, and (2), the actors doing and managing this flow of activities, the service operation. As service logistics, innovating telemedicine procedures after hip arthroplasty involves accordingly economizing through redesign this workflow. This, however, is in accordance with figure three not completely straightforward. We cannot proceed with deterministic thinking, following a planning paradigm. Researcher sensitivity to service fulfilment *chaos* is vital. The healthcare service process is viewed in this approach as *emergent* due to its contingencies. Importantly, healthcare service provision; no two such service processes are at any time completely alike. It is complex and depends on features and workings of its environment as a layered phenomenon.

To improve innovate telemedicine procedures after hip arthroplasty we need to elaborate on features of healthcare operations, as a form of service logistics. Research needs therefore to be founded on service industry particularities important in economizing healthcare logistics. Emphasizing "logistics" means focus on the service as a flow. A flow is metaphorical and directs focus to process as a series of transformations. Value in logics is measured in relation to transformation as pooling resources including people to create the service. This is different from physical distribution of goods, where transformation is associated with the transformation of a product in the flow. In services the service output is difficult to measure. The resources that crate the service and how they are coupled together and thereby interact, is measurable.

To analyse the state of a healthcare service process we propose considering features of networked interdependencies. This is a network of people and resources where interfirm boundaries is regarded as a contextual factor. Within contingency theory Thompson (1967) later, Stabell and Fjeldstad (1998) have developed an approach focusing on the role of power relations in the supply chain that enhances service industry particularities enabling process development schemes better adapted to service. Furthermore, the embedded nature of healthcare in society call for ecosystems thinking (Capra and Luisi 2014). Ecosystems direct attention to features of service sustainability and integrating a range of societal concerns associated with a studied healthcare service.

Services are commonly classified as intangible, heterogenic, inseparable, and perishable hampering according to Spring and Araujo (2009) a comprehensive analysis. Fundamental to this critical view of using a static classification of services in academia is that service production demands a different form of organising of the resource structure and processes within this structure (Chase and Garvin, 1989; Oliva and Kallenberg, 2003). People are fundamental to value creation in services (Grönroos, 1990; Normann, 2001). This is highlighted in the more recent service-dominant logic that highlights the importance of customer value in supply (Lusch and Vargo, 2014). Service supply chains are according to Sampson and Froehle (2006) bidirectional in nature. This means that interaction is a key feature of service supply chains. In service processes the customer provides significant inputs into the production process (ibid.). Sampson and Froehle (2006) also point out that from a supplier's perspective the quality of customer inputs in the service process interactions can vary. According to Sampson and Froehle

(2006), three types of customer inputs can be found in services: (1) the customer person, (2) physical resources such as customer belongings, tools and other tangible objects, and (3) information. These resources are pooled and used in combination to produce a service. In healthcare the customer value aspect is usually not only the patient, but also next of kin. This is especially when the patient is incommunicative due to the illness. In cases of hip arthroplasty, however, it is expected that the patient is a communicative actor the healthcare service providers can interact with.

Sampson and Froehle (2006) site empirical evidence of quality issues predominant in the service supply chains including (1) random arrivals, (2) inconsistent specification, and (3) varying input quality that influence service processes as capacity and demand management and quality management. From a Lean perspective Bicheno and Holweg (2009) point to typical forms of waste (muda) found in services are represented by (1) delay, (2) duplication, (3) unnecessary movement, (4) unclear communication, (5) incorrect inventory, (6) poor customer service, and (7) transaction and production errors. To support quality service provision tools such as reservation systems, price incentives and promotion of off-peak demand, and customer self-service are may be used. In addition, capacity management involves a mix of resources such as people, tools and goods.

A key feature of the supply chain is that it is a network consisting of multiple interconnected actors [29]. When approaching how to understand the nature of healthcare process contingency in relation to the supply chain context, analysis is dependent on revealing and the analyst thus understanding the nature of this context (Christopher, 2016). One of the key features of any network is the strength of coupling between the network entities. Following Weick (1976), network interactions take place through business relationships where this coupling varies on a continuum ranging from weak to strong. The nature of coupling impacts importantly on the loyalty of actors in the network, which then again may be viewed as expression of degree of power and trust; the "network atmosphere" (Gadde et al. 2010). Following Thompson (1967), a fundamental reason for networking is associated with interdependency between actors. Resources are scarce. Investments have made production resources specialized to a single firm. These actors need to interact to produce. Trading is a fundamental defining feature of the industrial network, the supply chain. Emerson (1962) points therefore out power as the fundamental characteristic of network interaction. These supplier or customer relationships can also be characterised as degrees of being imbalanced or balanced. Following Pfeffer and Salancik (1976) supply control is based on a mix of resource ownership, access, use and ability to make the rules regarding resource use. Power is often associated with coercion. Based on the writings of the process-focused sociologist Elias, Stacey (2003) argues how power both enables and constrains in production processes in industry. According to Pfeffer and Salancik (1976) and Leonardi ET AL (2013), interdependencies can be managed, be increased, reduced, or the dominant interdependency in a dyadic relationship changed. Contingency theory is not limited to explaining how production is an emergent phenomenon. Managing interdependencies of the network context is, following contingency theory, the core feature of strategic corporate management. This represents a longer term understanding of producing e.g. services, that it is the context that needs to be invested in to change process.

Interdependencies are impacted by uncertainty which is defined by Burns and Stalker (1961) as the ignorance of the person who is confronted with a choice about the future in general, and in particular about the outcomes of which may follow any of his possible lines of action. Interaction helps soothe uncertainty through exchange mechanisms; fundamentally involving information sharing (Pfeffer and Salancik, 1978). Mutual adjustment is typical of the reciprocal interdependency that characterises services (Stabell and Fjeldstad 1998). Mutual adjustment through human interaction is a time-consuming form of organisation. It is also costly in cases of high salaries. Alternatively, services may be increasingly pooled using mediating technology. This implies increasing standardization in the network. Since services are predominately characterized by reciprocal or pooled interdependence (Thompson 1967; Stabell and Fjeldstad 1998), automating service processes entail increasing strategically pooled interdependence by reducing reciprocal interdependence in individual or sets of business relationships. Managing interdependency provides a pathway to increased service process efficiency.

Ecology is fundamental to an ecosystem. Ecology was conceptualised by Haeckel (1866) as the science of relations between organism and the surrounding outer world. "Ecosystems" indicate accordingly considering nature, society and business as integrated from a system's perspective. Systems thinking finds its roots in the natural sciences, based on observations of how biological organisms' function. As Capra and Luisi (2014) state that "...nature does not show us any isolated building blocks, but rather appears as a complex web of relationships between the various parts of a unified whole". Systems are found in nature regardless of the glasses the researcher wears. In sum, an ecosystem understanding of healthcare processes implies using systems thinking encompassing economic, societal and nature concerns; an expansion of systems border that entails increased complexity.

One of the fundamental characteristics of interdependencies as discussed by Thompson (1967) approach is that this lies within systems theory. Ecosystems represents fundamentally system thinking meaning function, interconnectedness and system boundaries are core features when describing phenomena. Thompson's (1967) discussion, is however, limited to systems of industry. This does not encompass a wider scope of society and nature. Healthcare is clearly associated with a societal function. Furthermore, healthcare concerns the human body. Ailments may well be caused or treated by features embodied by the concept of "nature". Thompson (1967, p. 10) states that "...we will conceive of organizations as open systems, hence indeterminate and faced with uncertainty, but at the same time as subject to criteria of rationality and hence needing determinateness and certainty". Management understanding the nature of interdependencies is associated with increasing rationality in decision-making in the network. However, interactions in a healthcare service producing network accounts for only a part of these influences. Following Leonardi et al. (2013), interdependency changes subject to incremental and iterative adaptations in the context of the healthcare "supply chain" and a wider social and natural environment. While business systems tend to conceptually be governed by management, ecosystems places weight ion how both nature and society together interplay making the system more self-governed; more out of reach to the manger.

Expanding healthcare services management to regard it as an ecosystem involves taking account of not only interaction in the supply chain network to manage the workflow, but to expand management discourse to encompass also societal and nature concerns. A direct impact of this expansion is not only widening the scope of systemic description and investigation, but also expanding the researched time frame. Since ecosystems are associated with sustainability, this means that the time frame of analytical scrutiny is expanded to considering interests of future generations. Furthermore, an ecosystem will be forming the perspective of the manger be perceived as uncertain and inherently complex. Ecology has its own logic of organising that may be different from that of mangers, e.g. in a hospital. Based on Engelseth and Kritchanchai (2018) management particularities of healthcare services consist of these three service production aspects:

- *Structure*: production pools various interlinked resources in an integrated network structure embedded in society and nature. This describes the *pooled* interdependency.
- *Dynamics*: managing these services demands through resource pooling demands interaction. This represents the *reciprocal* interdependency. The higher the uncertainty in how to configure resource pooling, the higher the reciprocal interdependency. This is the core of production, the activity value-making process.
- *Learning and development*: Service quality is poor much due to the complex nature of services process coupled with weak understanding of managing services as emergent phenomena. This represents the *sequential* interdependency. Learning and development fundamentally follows the timeline of production and is embedded in the network context the actor knows, and the wider unmanaged societal and natural environment. This is the long-term aspect that ensures the quality of production context. Development of capacities, people, tools including information systems, are examples here.

It is the context of "learning and development" aspect that application of telematics is considered. It is important to remember that all these aspects are interconnected. Our case description will therefore describe the structure and then the dynamics of procedures after hip arthroplasty to consider the use of telemedicine technology to develop this healthcare process.

3 Number of hip and knee arthroplasty in Poland

We now consider the empirical realm of this study. Hip arthroplasty takes 64,62 % of all joint replacement operations in Poland. Second place takes knee arthroplasty reaching 33,97 % in 2018 year. Since 2005 year there is constant increase in realization of total hip arthroplasty procedures in Poland refunded from National Health Fund (NHF), from 26 082 in 2005 year to 56 983 in 2018 year (Fig. 1). In absolute numbers, the highest increase in joint arthroplasty is observed in the case of hip joint.

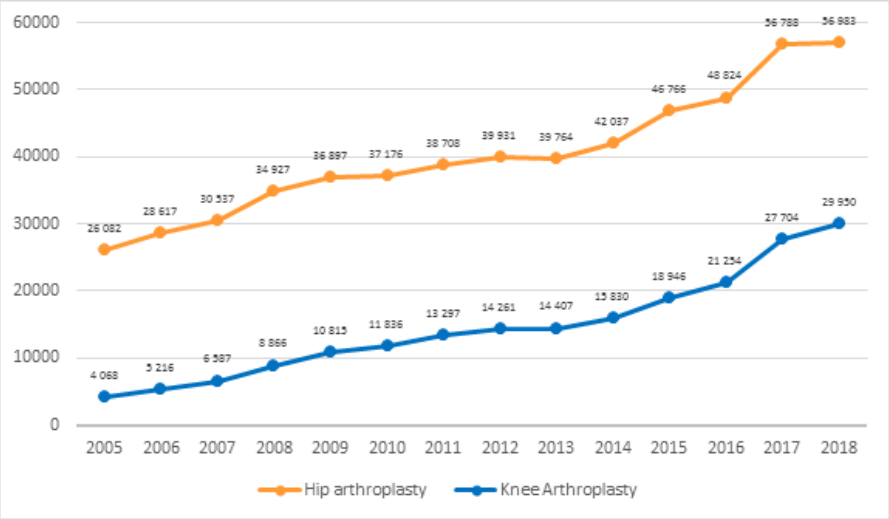

Fig. 2. Number of hip and knee arthroplasty procedures conducted in 2005-2018 in Poland according to realization report from National Health Fund.

A hip replacement procedure is more often performed than knee replacement (Fig. 2). For a hip replacement procedure average age of operated woman is 71 years old and 65 years old for man. Also, worth mentioning is that the largest share in total number of operated people were patients aged 60-69.

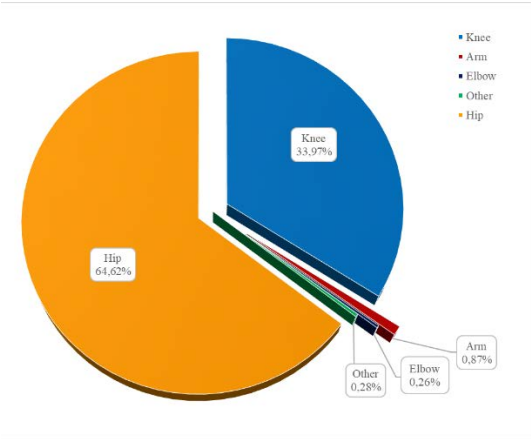

Fig. 3. Percentage share of individual types of arthroplasty procedures conducted 2018 in Poland according to realization report from National Health Fund (Realization, 2018).

In the period from 2005 to 2018 year number of arthroplasty procedures increased as well as costs of those operations. In the mentioned period there was 5 billion PLN spent for hip and knee arthroplasty together.

Healthcare services as a form of operations management (OM), is poorly developed and thus inefficient (Haszlinna and Potter, 2009; Hall 2013). Healthcare management involves physical distribution challenges such as inventory management and transportation costs. Healthcare is, however in relation to OM, predominately a service production. Instead of following a flow of goods, a workflow is the essence of transformation in time, place and form. A study by Butt and Run (2010) pointed out the weak state of information management infrastructure in hospitals. Patients in this study rarely receive the right service at the right time, indicating flow malfunction. This is much due to poor planning and management supported by insufficient healthcare information systems (HIS). Leng (2010) reveals how even though a government prioritises healthcare services hospitals continue to cope with frail healthcare services performance including a long treatment cycle. According to Parker (2000): "Measuring performance is something that all organizations do". This implies that measuring healthcare service performance supports healthcare management in the evaluation, control, personnel guidance, organisational learning and process improvement. Introducing an effective performance measurement system in healthcare entails that quality shortfalls can be detected on a daily and continuous basis more supporting efficiency in quality shortfalls detection and thereby efficient process improvement (Purbey et al. 2007). It is according to Baker et al. (1998) an important aim in healthcare services to improve service performance. Providing healthcare services operations that provide the appropriate service for its recipients is vital to ensure patient value. Haux (2015) therefore states that improving HIS to support healthcare series is therefore a priority in many countries. This study approaches developing healthcare services as a process integration problem. This implies modelling the flow of healthcare services within and between networked actors.

4 Technology review for telemedicine procedures after Hip Arthroplasty

Telemedicine is defined as a technological and organizational solution for patient care, in particular:

1) remote contact of a specialist with a patient,
2) remote specialist-specialist consultation,
3) measurement and data transfer between devices,
4) information sent by devices to the patient and/or specialist,

provided that the obtained results of measurements, tests, conversations, analyzes and information sent in an electronic form are recorded. Reimbursed by National Health Fund services in Poland are in the field of cardiological telerehabilitation and teleconsulium in senior care.

Telemedicine thanks to technology develops faster and faster. The field is worth to conduct research because of possibility to prepare better solution which can help doctors and patients. We have a lot of types of technology being used in telemedicine. The most important of those are: Teleconsultation, Teleeducational platform, Alarm de-

vices, E-registration, E-results, Telerehabilitation (example in cardiology) and Teleradiology. Below we try to briefly characterize possible use of those technologies in telemedicine.

Teleconsultation can be performed as simple technological solutions as chats or chatbots. More advanced usage are video consultations – there are more electronic devices needed like cameras, storage servers, internet connection (Vesterby 2017). The most complicated solution are e-offices with results commented online where we need not only technical equipment, but proper organization is a must have. Teleradiology is implemented through remote medical images descriptions. Is possible to use tool to converse Artificial Intelligence to analyze breakage of bones and soft tissue injuries in the technology of 3D being a support for MD (Disior startup, Nordic Insights 2018).

Examples of wearables for domestic healthcare:

1. Collapse wrist band (Noomi Case Study, Swedish startup, Nordics Insights 2018) – band equipped with collapse sensor, changes in diet and sleep process ready to analyze behavioral patterns.
2. AppleWatch – device measurng pulse, blood pressure and temperature, physical activity and detecting atrial fibrillation (apple.com)
3. LifeWristband - Furnished with Life Button alarm that connects to the Remote Medical Care Center to call for help.
4. ECG recording device with telemedicine function that permits patient geolocation and Holter ECG for longer periods.
5. CTG device - Telemedical cardiotocography performed at home.
6. CardioVest. - Non-invasive monitoring for early detection of silent atrial fibrillation (AF) detection (comarch.com)
7. StethoMe® - system that detects abnormalities in the respiratory system relying on medical AI algorithms working with a wireless stethoscope and dedicated application. (stethome.com)
8. High-precision non-contact sleep sensor for professional sleep recording, measuring, analysing and improving personal sleeping habits and recording of heart rate, respiratory rate and movement (beurer.com)
9. Digitsole connected footwear - smart insoles detecting neurological diseases, indicating how increase performance and warn against injury while physical activity (digitsole.com).

5 The value of telemedicine market in Poland

The value of the global telemedicine market in 2018 was estimated at USD 34.28 billion. At the same it is anticipated that by 2026 this value has a range of up to USD 185.66 billion (Telemedicine, 2019). The telemedicine sector in Poland is a market in the growth phase. Currently, its value is approximately PLN 44 million (2018) and is expected to increase by 29% till 2023 (Market 2018). Following types of telemedicine procedures are refunded by National Health Fund in Poland (Open Health, 2018):

1) geriatric teleconsilium,
2) cardiological teleconsilium,

3) hybrid cardiological telerehabilitation.

The sector is characterized primarily by: a high level of uncertainty and risk of operations, variable prices, large capital needs to finance operations, which is caused most of all by the introduction of technology and innovation with relatively low competition. Therefore, estimating the costs of using telemedicine tools is not easy, especially in the public system as only a few benefits are financed by the National Health Fund (e.g. cardiological teleconsylium and geriatric teleconsylium). The "reluctance" to finance telemedicine services by the public sector arise, among others, from the economic approach to the valuation of guaranteed services. Telemedicine itself does not generate income but it is worth identifying and estimating the costs of lost benefits and/or financial and time savings. If subsequent telemedicine services were to be included in the guaranteed benefit package, cooperation between service providers and the public sector as well as producers of telemedicine solutions is necessary. Only comprehensive cooperation will allow conducting pilot programs to assess the effectiveness of these solutions, as well as to estimate the actual costs of using telemedicine solutions. According to the National Health Fund data (National 2019), expenditure on health care in 2019 was to be about PLN 95 billion, while the finance allocated for the development and introduction of innovation is marginal. At the same time, it is worth noting that the data from the "Patient in the digital world" report indicate that 60% of patients living in Central and Eastern Europe (with revenues over EUR 300 net per month) declare their willingness to use telemedicine tools such as teleconsultation, telediagnostics, telemonitoring and telerehabilitation. Furthermore, in the literature, the indicated costs of using telemedicine in global terms are only estimated costs due to lack of uniform methodology of comparative research in this area and the fact that the same device can be used for another purpose, and therefore the costs of its use in another case may vary.

6 Conclusion

The case description shows that using telemedicine technology in essence is an emergent process. This implies that a key feature of developing telemedicine use is enabling flexibility in the healthcare service workflow, it production. In practice developing such flexibility may involve using telemedicine technology to support both in preparation for medical treatment as well as in post-operative period. Determining the potential market for telemedicine solutions in Poland are:

- Hip joint is the most common joint replacement. This shows that it is worth taking a closer look especially for this procedure.
- Reports of arthroplasty operations refunded for NHF shows that the number of operated patients increases every year. Due to high cost of procedure and proven impact of i.a. rehabilitation before and after operation, control visits, there is a need to consider implementation of technologies to economize via domestic healthcare influencing on the results of operation and health benefits for patients.
- Waiting list to hip arthroplasty procedure at NHF varies between few weeks and few years (terminyleczenia, 2019).

- Third most commonly reported health problem by older people is osteoarthritis. Saying this it is important to mention that the advanced osteoarthritis is the medical indication for joint replacement (Information, 2018).

Another factors, which are very important in telemedicine implementation are: socio-cultural, economical, legal (regulation on the protection of personal data), technological. We must also remember about the limitations of implementing telemedicine technologies such as (Kozlowski et al., 2015):

- make sure that the new technologies can be easily integrated with the technologies that had already been used,
- check if the users have sufficient knowledge and skills to operate the new technologies,
- check if users of the technology did not report any defects or if there were no instances of technology's breakdowns.

In order to overcome these barriers, all interested parties should be involved and the potential of universities should be used to support research (Kozlowski et al. 2012) into the processes of implementing telemedicine processes in specific patient groups such as e.g. patients after hip arthroplasty. In practical terms development should be sensitive to that environmental factors are two-layered as described in figure 1. The context represents the, by healthcare institutions, governable environment. It works a s a buffer in relation to uncertainty in the healthcare process itself and wider environmental uncertain such as technology change, epidemics, regulations etc. The context represents a realm of investment in human resources and technology. Given the nature of uncertainty in healthcare service production, this is where healthcare institutions should direct their focus of development. They should not focus on developing the process first, since this will follow investments. They should neither direct focus to changing the wider environment since this is an unruly entity. Rather investments should enable healthcare process responsiveness to the wider environment and healthcare process change.

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