

Patient-centered Coordination in Healthcare Service Networks

Measuring and Improving Inter-organizational Information Flow

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Abstract

In 2012, more than 900 million people worldwide suffered from chronic diseases, disabilities, or functional limitations. For this ever-growing number of patients that need long-term care from multiple service providers, coordination is indispensable for efficient – often also for effective – healthcare service delivery. This strong degree of organizational differentiation requires coordination among multi-faceted, independent stakeholders. In the past decades, intra-organizational effectiveness and efficiency of healthcare delivery has been improved by information and communication technologies (ICT). The potential of ICT is also promising for facilitating inter-organizational information flow and, thus, avoiding unnecessary expenditures and improving patient health. In inter-organizational settings simply introducing ICT into current modes of healthcare practice yields only limited benefits because of entrenched work practices and existing subtleties. Furthermore, comprehensive ICT adoption, inter-organizational information management, or industry-wide standards are hard to develop because of divergent requirements and complex legal barriers.

Therefore, this thesis takes a different approach and investigates the idea of a coordination service that improves the information flow between the independent stakeholders along the patient care pathway. It investigates the impact of such a coordination service in a healthcare service network (HSN), i.e. an inter-organizational network of independent healthcare stakeholders. In doing so, three research questions are addressed. First, inter-organizational healthcare networks are investigated. The notion of coordination in such settings is explored by drawing from the literature of organizational theory, service science, and information systems to operationalize healthcare service quality. Second, functions and requirements of a coordination service that improves the information flow in an HSN are investigated. Following a service engineering approach, such a coordination service is developed and its components are validated in a case study setting. Third, the long-term impact of the coordination service is analyzed by evaluating its effectiveness, efficiency, and acceptance in an 18-months randomized controlled trial in the German region Rhön Grabfeld.

Based on identified requirements regarding process, ICT-structure, and legal constraints, a stroke-specific coordination service was developed, validated, implemented, and evaluated. The devised service is of socio-technical nature and provides incentives for all involved stakeholders to share information, thus serving as a hub/agent that distributes information. The service consists of a person supported by a workflow management system, cloud-based healthcare IT, and telemedicine devices. The proof-of-concept implementation and subsequent case study validation provides a deeper understanding of inter-organizational coordination in healthcare. More importantly, long-term impact results show that a patient-centered coordination improves healthcare service quality in an HSN. In the trial, study group patients' health-related quality of life and competences were significantly improved compared to a control group that received the "usual care." On average, study group patients knew more available healthcare services, reported less information deficits, and a significantly higher time trade off value that describes their perceived health-related quality of life. Furthermore, health-economic analysis and acceptance assessment show that the service has a positive cost-benefit ratio and is accepted by the involved stakeholders, respectively. The developed and evaluated service blueprints for the coordination service can be adapted to other settings or diseases.

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List of Abbreviations

ADL	Activities of Daily Living
BI	Barthel-Index
BN	Business Network
BPMN	Business Process Modeling Notation
CBA	Cost Benefit Analysis
CEA	Cost Effectiveness Analysis
CG	Control Group
CM	Case Management
CRM	Customer Relationship Management
CUA	Cost Utility Analysis
DMP	Disease Management Program
EQ-5D	EuroQol-5Dimensions
FO	Final Outcome (Indicator)
GDP	Gross Domestic Product
HMO	Health Maintenance Organization
HRQOL	Health-related Quality of Life
HSN	Healthcare Service Network
HSQ	Healthcare Service Quality
IC	Integrated Care
ICT	Information and Communication Technology
IHIP	Inseparability, Heterogeneity, Intangibility, Perishability
IO	Intermediate Outcome (Indicator)
IS	Information Systems
LSC	Linear Supply Chain
mRS	modified Rankin Scale
NBN	Neurological Clinic in Bad Neustadt a.d. Saale
PHR	Patient Health Record
PMR	Patient Medical Record
PSMC	Patient Self-management Competences
QOL	Quality of Life
RCT	Randomized Controlled Trial
SaaS	Software-as-a-Service
SBN	Smart Business Network
SC	Supply Chain
SG	Study Group
SHB	Stroke Health Book

SME	Small and Medium Enterprises
SVN	Service Value Network
TAM	Technology Acceptance Model
TTO	Time Trade Off
TUHS	Timely utilization of healthcare services
UTAUT	Unified Theory of Acceptance and Use of Technology
VAS	Visual Analogue Scale
WHO	World Health Organization

Part I

Preliminaries & Fundamentals

Chapter 1

Introduction

In 2025, more than 30% of the population of developed countries will be older than 65 (WorldBank, 2012) and more than 40% of the population will have a medical condition that needs constant care (World Health Organization, 2012). Chronic diseases are already the leading cause of death and disabilities worldwide: Of the 58 million deaths in 2005, approximately 35 millions were the result of a chronic disease (World Health Organization, 2005). More than 900 million people worldwide suffered from chronic diseases, disabilities, or functional limitations in 2012 (World Health Organization, 2012). Notably, more than 125 million people in the United States of America and more than 150 million people in the European Union need constant care (World Health Organization, 2012). Patients suffering from one or more chronic conditions require long-term care involving multiple healthcare service providers (Hofmarcher et al., 2007; Johnson and Burik, 2010). According to recent studies, patients in the western world visit on average two primary care physicians and five specialists every year – apart from ambulatory service providers like rehabilitation facilities, social services, and other outpatient service providers (see for example (Pham et al., 2007; OECD, 2012; World Health Organization, 2012)). For example, in Germany people that suffer from chronic diseases visit outpatient physicians, i.e. primary care physicians and specialists, an average of 40 times per year (OECD, 2012; den Bussche et al., 2011). Coordinating many of these healthcare service providers is crucial for efficient – often also for effective – healthcare service provision (Kaplan and Porter, 2011). This coordination means "managing dependencies between activities performed to achieve a goal" as described by Malone and Crowston (1994).

Expenditures on healthcare make up a large, and ever-growing, part of the gross domestic product (GDP) of countries all over the world. For instance, in 2010 they made up an estimated 17.6% in the USA and 9.0% in the EU (OECD, 2012; World Health Organization, 2012). Constant expenses caused by chronic diseases are a large share of these expenditures (OECD, 2012; World Health Organization, 2012).

Most notably, the direct costs for treating cardiovascular diseases are high (Lloyd-Jones et al., 2010). Following the economic crisis of 2008 many western countries reduced health spendings as part of broader efforts to reduce budgetary deficits. In 2010, the USA and the EU stabilized their overall healthcare spendings per capita respectively at \$8,233 and \$3,268 (OECD, 2012). However, this is only a temporary stabilization. Due to the demographic shift, prevalence rates for chronic diseases rise for an increasing number of people (WorldBank, 2012). Subsequently, more people will suffer from chronic diseases in the future, and thus, more people require effective and efficient care coordination. Therefore, improved management of chronic diseases is an acknowledged health policy priority for many countries (Bodenheimer, 2008). Caused by budgetary constraints, increasing efficiency of healthcare – particularly improving care coordination – is given high attention as means to further stabilize or even reduce healthcare spendings while improving healthcare quality (Ovretveit, 2011; Schang et al., 2013).

The lack of coordination between various independent stakeholders is widely considered to be one of the key causes for poor healthcare quality and unnecessary costs (Bodenheimer, 2008; Leutz, 1999; Schang et al., 2013). Current healthcare systems are mostly aligned on acute treatment and, thus, coordination across organizational boundaries is difficult to achieve (Anderson and Knickman, 2001; Ovretveit, 2011). Often, healthcare stakeholders do not coordinate their activities because they are missing the incentives, the structural conditions, or the organizational setup to do so (Washington et al., 2011). This causes adverse events, which range from duplicate and wasteful treatments to potentially life-threatening conflicts from the treatment plans of different physicians (Hofmarcher et al., 2007; Porter and Olmstead Teisberg, 2006; Kaplan and Porter, 2011). Furthermore, even though the healthcare system's purpose is to improve patient health, patients are rarely put at the center of its activities (De Blok et al., 2010; Schang et al., 2013). The emphasis is rather put on system processes than on patient-centered healthcare delivery (Anderson and Knickman, 2001; Haux, 2006; Berwick, 2009; Wilson et al., 2012; Sun et al., 2013) that enables patients "to have access to the right care at the right time" (Schang et al., 2013). For example, (Olivera Marjanovic, 2011) reports that improving healthcare process efficiency in terms of business process improvement does not necessarily improve the quality of patient care.

Even though it has been acknowledged by researchers and practitioners alike that uncoordinated care wastes resources and affects patients' health, the current healthcare systems are still far from providing optimally coordinated healthcare services, especially in inter-organizational settings (Porter and Olmstead Teisberg, 2006; Winter, 2009; Kaplan and Porter, 2011; Bodenheimer, 2008; Schang et al., 2013). To overcome these problems, a simple yet effective coordination mechanism is found in information sharing (Choe, 2008). In fact, information asymmetries be-

tween the healthcare stakeholders have been proven to be one of the major obstructions in coordinated care (Bodenheimer, 2008). Particularly information deficits on the patient side make it difficult for them to locate the right service at the right time (Washington et al., 2011; Bhandari and Snowdon, 2011). Information and communication technologies (ICT) offer promising potentials in this scenario, especially with respect to patient self-management competences and cooperation between different healthcare stakeholders (Fichman et al., 2011; Davoody et al., 2012). For example, the US-President's Council of Advisors on Science and Technology (PCAST) clearly states that among other initiatives, the government should enforce ICT-initiatives that facilitate patients becoming more involved in their own care and that provide clinicians with information¹. However, introducing ICT into current modes of inter-organizational healthcare practice will yield limited benefits because of entrenched work practices and existing subtleties in healthcare processes (Winter, 2009). Moreover, coordination is dependent upon the local context, so the implemented ICT varies in each different healthcare system and in the different settings within the system (Ovretveit, 2011). The real opportunity is to utilize ICT to transform the process of care delivery along the complete patient care pathway (Kobb et al., 2003; Porter and Olmstead Teisberg, 2006).

Instead of pursuing top-down approaches that aim at nation-wide information integration, coordination problems might be solved by "care coordinators" that act locally (Meijboom et al., 2010). Considering such a care coordinator as an independent service expands traditional communication channels, which currently mostly focus on healthcare service providers, by a patient-centered perspective across organizational boundaries along the complete patient care pathway. This kind of care coordination has been proven to have a positive impact on healthcare quality and, consequently, on patients' health (Abraham and Rosenthal, 2005; Bodenheimer, 2008; Cameron et al., 2008; Wissel et al., 2011; Heijnen et al., 2010). By providing information to the involved healthcare stakeholders, patients and healthcare service providers alike, such a care coordination service increases the timely utilization of beneficial healthcare services while decreasing unnecessary or duplicate services (Bodenheimer, 2008; Cameron et al., 2008). It therefore provides a valid option to improve the efficiency of healthcare delivery and to save costs for patients, healthcare service providers, and the society as a whole. Such coordination reduces direct costs which incur during the treatment and it also mitigates secondary costs if, for example, the patients recover faster and go back to work earlier.

¹Stated in the report to the president realizing the full potential of the health information technology to improve healthcare from 2010, available at <http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-health-it-report.pdf> (last accessed December 2013)

Until now, ICT usage in these settings has not been fully investigated (Davoody et al., 2012; Kobb et al., 2003). The analysis of inter-organizational care coordination and ICT usage is the focus of this thesis. The following section derives research questions that enable the exhaustive analysis of the existing healthcare settings, the coordination service development, and the coordination service evaluation.

1.1 Problem Description & Research Questions

Pursuing a coordination service approach to facilitate information flow between healthcare stakeholders is the core research activity in this thesis. It is dedicated to a service-oriented approach aiming at improving inter-organizational care coordination, particularly for patients suffering from chronic conditions. The overarching question investigates the characteristics of such a coordination service and its long-term effects. In general, the challenges regarding coordination are multifaceted. They range from simple cooperation issues, such as lack of trust or threats to autonomy, to situational conditions like uncertain benefits, to organizational structures that might impede resource allocation. In healthcare, these coordination challenges are amplified because healthcare services are often highly individualized and sometimes even disease-specific (Berry and Bendapudi, 2007). Providing healthcare for patients suffering from chronic diseases generally requires very different professional disciplines in terms of knowledge, expertise, and cultures, e.g. doctors, nurses, and administrators (Vargas Lorenzo and Vazquez Navarrete, 2007). There is a wide range of treatment options depending on the medical condition (diabetes, congestive heart failure, cerebrovascular diseases etc.) and the patients' individual traits as well as medical history. Additionally, each treatment option is often performed by different, specialized organizations. Advances in medical knowledge and technology further foster the already strong organizational differentiation and specialization in modern healthcare systems.

In order to improve care coordination, the benchmark needs to be defined. Assessing the effects of coordination in such an inter-organizational setting depends on the perspective because it involves a large number of stakeholders with conflicting interests that treat various medical conditions of the same patient at different points in time. The various stakeholder groups such as patients, providers, payers, and regulators appraise the coordination effects differently. For example, a patient rather wants to take advantage of more healthcare services than advised. Whereas, the payers such as insurance companies have the opposite point of view.

Due to the historically evolved acute treatment focus of the healthcare domain, contemporary approaches to coordination take an intra-organizational perspective,

i.e. the provider perspective (Anderson and Knickman, 2001). Even when explicitly dealing with the acute treatment of chronic patients, contemporary approaches often do not take the complete patient care pathway into account. Consequently, the transition processes and the viable information flow between organizations is often neglected (Washington et al., 2011). Since patients that suffer from chronic diseases take advantage of multiple healthcare service providers and information flow between the involved providers is often insufficient, coordination of different healthcare service providers is of great importance for these patients (Johnson and Burik, 2010). Here, a more patient-centered perspective that takes the complete patient care pathway into account while facilitating the information flow in a network of independent healthcare stakeholders is necessary (Berwick, 2009; Kaplan and Porter, 2011; Wilson et al., 2012).

In line with the intra-organizational focus, contemporary literature generally focuses on the provider's perspective for the evaluation of coordination. This may lead to adverse events, for example, (Olivera Marjanovic, 2011) reports that improving healthcare process efficiency in terms of business process improvement does not necessarily improve the quality of patient care. Therefore, in this work the patient rather than the healthcare service provider is put at the center, which was advocated by several proposals on care provision (De Blok et al., 2010). Thus, this thesis addresses three problems.

1. There are no commonly accepted measurement frameworks to evaluate the coordination effects in such a network in terms of service quality and patient health. In addition, it is unclear how to characterize the independent healthcare stakeholders along the complete patient care pathway and their connection.
2. Even though "central care coordination" has already been proposed as a remedy to the existing information asymmetries, the characteristics of such a coordination service have neither been described nor validated.
3. Apart from theoretical considerations, the impact of a service which tackles the coordination problem in a network of independent healthcare stakeholders has not been investigated in detail for a long time period. It is unclear how effective, efficient, and accepted – particularly with respect to the ICT components – such a service is in a real-world scenario.

The work at hand investigates the idea of a service that facilitates information flow between the healthcare stakeholders along the complete patient care pathway. In contrast to the majority of the state-of-the-art healthcare approaches, which assume that all the involved stakeholders either use a common ICT or a mutual infor-

mation management can be enforced by hierarchical power (Winter, 2009), the service is designed to work independently. The service aims at increasing healthcare's effectiveness and efficiency along the complete patient care pathway. Especially for patients suffering from chronic conditions, it is important to take the complete care pathway into account instead of just looking at isolated parts of it (Porter and Olmstead Teisberg, 2006). This inter-organizational setting involves several independent healthcare stakeholders, which form a network along the patient care pathway that is subsequently referred to as healthcare service network (HSN). The stakeholder-independent quality of such an HSN regarding the structural components, the processes, and the patient health is referred to as healthcare service quality (HSQ) in the following paragraphs.

Since investigating coordination within an HSN strongly depends on the viewpoint, the different perspectives must be elaborated. Thus, Research Question 1 deals with the coordination in an HSN, thereby addressing the first problem stated in the previous paragraph. It investigates what needs to be coordinated and how this coordination can be improved – particularly using ICT.

Research Question 1 <OPERATIONALIZATION OF COORDINATION IN A HEALTHCARE SERVICE NETWORK >. *How is coordination operationalized in a network of independent healthcare stakeholders in order to assess its quality?*

To study Research Question 1 exhaustively, this work bridges the research fields of organizational theory, information systems, and service science. It draws upon the healthcare-related literature in those research fields to examine the concept of healthcare service quality from a network level, and investigates the concept of patient-centered healthcare service networks. There are many frameworks describing the quality of healthcare services, of which some have never been used in practice. Investigating how HSQ can be measured with respect to the inter-organizational coordination efforts is this thesis' first contribution. The conceived HSQ concept is based on various theoretical perspectives without necessarily integrating them into a grand meta concept. Similarly, the HSN model is introduced and delineated against existing network concepts in healthcare. For example, conventional concepts of service networks, business networks, or supply chains do not take into account that in healthcare the customer, i.e. the patient, has several unique characteristics (Berry and Bendapudi, 2007). Even though these theoretical considerations are necessary for locating and delineating this work in contemporary literature, this work's focus is not put on a hypothetical model but rather on how to

explicitly improve coordination in inter-organizational healthcare settings. This is achieved by sensibly integrating information and communication technologies in the existing inter-organizational healthcare processes, and by providing incentives to the involved healthcare stakeholders to exchange relevant patient data.

In healthcare, studies that incorporate both ICT and organizational aspects do not only highlight the complexity of the research area but also show that it is nearly impossible to find one single theoretical approach that can incorporate all different aspects (Winter, 2009). Therefore, after introducing the notation of HSN and HSQ, the existing coordination concepts in inter-organizational healthcare settings are described and assessed. Due to the knowledge-intensive nature of healthcare services and inherently high information asymmetries between the network's participants (Mooney and Ryan, 1993), information flow in the network plays an important role in determining its HSQ (Mäenpää et al., 2009). It has been argued that an independent service improves said information flow and, hence, the inter-organizational information management (Bodenheimer, 2008; Meijboom et al., 2010; Wissel et al., 2011). However, it is not clear what characteristics this service needs to possess. This issue is picked up by Research Question 2, which addresses the second research problem this thesis investigates.

Research Question 2 <CHARACTERISTICS OF THE COORDINATION SERVICE>. *What are the characteristics of an independent service that improves the information flow between the stakeholders of an HSN and, thus, the information management?*

Often, inter-organizational information and communication technologies, e.g. electronic medical records, have been proposed as the best solution to improve the inter-organizational information flow (Mäenpää et al., 2009). Although they have promising potentials to improve inter-organizational coordination, they are rarely adopted because of conceptual and technical complexity (Fichman et al., 2011). First, healthcare service providers neither have the economic incentives nor the technical expertise to exploit the advantages effectively. Second, since there are numerous highly specialized healthcare providers with individual ICT, many interoperability problems arise. In addition, low ICT-diffusion within the healthcare domain (Hill and Powell, 2009) induces supplementary usability problems (Bhandari and Snowden, 2011), which impair efficient ICT usage by healthcare service providers as well as patients. Third, legal factors additionally inhibit the adoption. There are legal barriers that warrant data confidentiality, security and accountability, and because of predetermined, legally-fixed standards there is a first mover disadvantage. For

an inter-organizational ICT-infrastructure to work, other organizations have to be incorporated, which means they can free-ride on existing ICT in a network. These three barriers lead to high initial costs paired with an uncertain outcome for introducing inter-organizational ICT (Mäenpää et al., 2009).

This complexity of inter-organizational ICT in healthcare persists when looking at inter-organizational information management, which is – for the most part – independent of the underlying ICT because it is deployed differently in different settings. Apart from the underlying ICT, i.e. the infrastructure, strategy and processes also have to be considered when investigating inter-organizational information management (Gericke et al., 2006). Since considering these three levels of information management possibly induces unforeseeable dependencies, the long-term effects of the coordination service are evaluated in addition to validating the service concept. Therefore, after postulating the coordination service's requirements and functions, it is put into practice in a hospital in Germany. The impact on the HSN is investigated in a real-world scenario. Research Question 3 addresses this impact evaluation.

Research Question 3 <IMPACT OF THE COORDINATION SERVICE>.

What is the impact of the developed coordination service on the healthcare service quality of a network of independent healthcare stakeholders when it is applied in a real-world scenario?

The service's effectiveness, efficiency, and acceptance are investigated in detail. Evaluating the effectiveness of the coordination service should not be confused with incentive engineering. Instead of looking for an optimal solution, this thesis investigates a feasible approach to coordinating independent healthcare stakeholders that improves the current situation. Therefore, the service's effects in terms of patient health and healthcare delivery process are compared with the "usual care" provided. Furthermore, the service's acceptance, i.e. the opinion of patients and professionals about the service, and its possible relation to the service's effectiveness is investigated. When evaluating the coordination service's efficiency, a health-economics perspective is taken. Whereas the former is simply confirmatory – does the service have the anticipated effects? – this part of Research Question 3 tries to relate the cost and benefits by investigating the incremental cost effectiveness of service in comparison with the usual care provided. Apart from the effectiveness and the efficiency, the acceptance of the involved stakeholders is also investigated. Particularly, the involved stakeholders' technology acceptance has a large impact on the usage and, thus, on the actual effectiveness of the coordination service.

1.2 Structure

The work at hand deals with the question of how to improve inter-organizational care coordination using a service-oriented approach. In detail, it investigates the following three aspects.

1. How to operationalize coordination in inter-organizational settings.
2. What characteristics an independent, inter-organizational coordination service possess.
3. What the long-term impact of such a coordination service is in a real-world scenario.

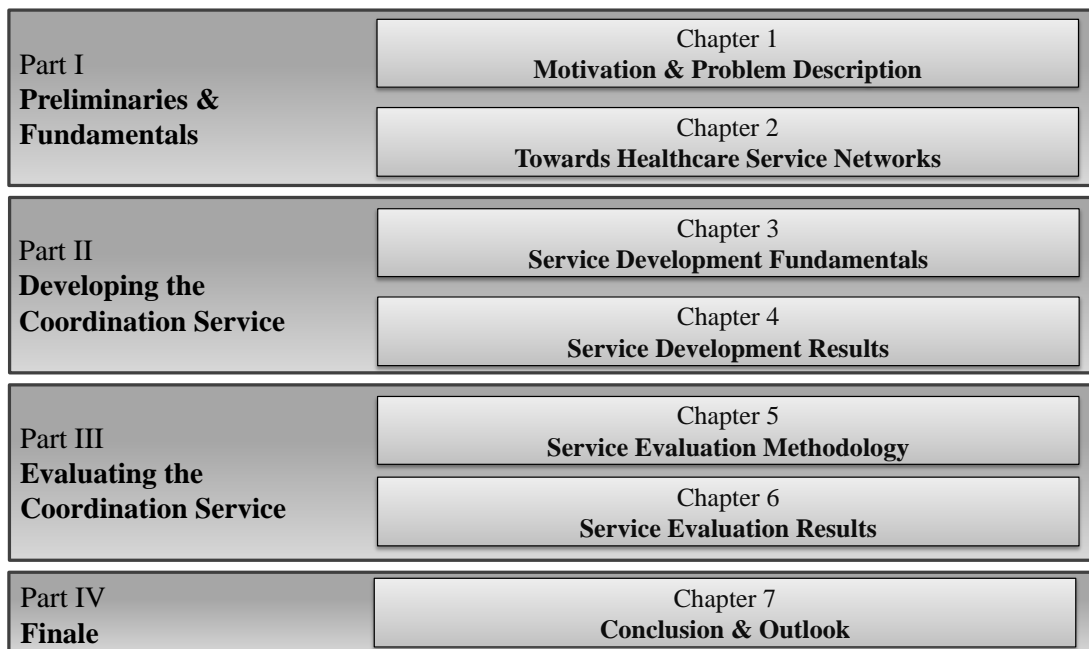


Figure 1.1: Thesis structure.

Consequently, the thesis is structured in three parts as illustrated in Figure 1.1. The first part deals with the theoretical fundamentals and mainly consists of foundations and theoretical contributions in the field of organizational theory. The second part presents the coordination service development. It comprises theoretical considerations, such as assessing service engineering approaches and the service development methodology, as well as more practical contributions, such as the validated characteristics of a coordination service. The third part is the service evaluation. It presents the evaluation setting and results of the coordination service's long-term impact. Moreover, this part includes the final conclusion with a summary, the limitations, and the future work. In Table 1.1 the purpose and the output of the thesis'

Chapter	RQ	Purpose	Output
1. Introduction	-	Motivate and introduce the subject	Motivation, problem description and research questions
2. Towards Healthcare Service Networks	1	Explore inter-organizational coordination with healthcare service focus	Research fundamentals, i.e. delimitation to state of the art and definition of healthcare service network
3. Service Development Foundations	(2)	Explore service development concepts and related work	Description of service engineering methodology and assessment of related work
4. Service Development Results	2	Investigate requirements and provide concepts for inter-organizational coordination in a healthcare service network	Requirements for an effective coordination service and validated components
5. Service Evaluation Methodology	(3)	Provide methodology and context for the coordination service's impact evaluation	Description of the service application in a real world scenario using the appropriate methodology
6. Service Evaluation Results	3	Provide empirical material to evaluate the coordination service's impact	Analysis of the service regarding effectiveness, efficiency, and acceptance
7. Conclusion & Outlook	all	Draw conclusions based on evaluation results	Summary, recommendations, suggestions for further research

Table 1.1: Summary of thesis chapters' contents with respect to the addressed research question (RQ).

chapters are shown in more detail. The table also relates the chapters to the three research questions, which are addressed in this work.

1.3 Research Development

Parts of this thesis were reviewed and presented at various academic conferences and workshops as well as published in the proceedings and in international journals. This section does not only give an overview of the published material, but also sketches the development and refinement steps that have taken place in the course of working on and writing this thesis. Furthermore, the research findings' impact and their integration in current research projects are discussed.

The first ideas regarding patient-centered support along the complete patient care pathway have been published at the German information systems conference Wirtschaftsinformatik WI 2011 in Zürich (Hartmann et al., 2011). In this paper, the

significance and characteristics of current research trends regarding health 2.0 applications have been elaborated, which have been capitalized in the research project easyCare². This literature review formed the initial hypotheses that patient-centered information provision solely relying on "decentralized" user-generated content will not provide the capabilities of solving the coordination problem in a healthcare service network. In the two subsequent publications "Productivity of Services NextGen - Beyond Output / Input" at the XXI International RESER Conference 2011 (Hottum et al., 2011), and "Patient-centered Coordination in Healthcare Service Networks" at the WI 2013 (Görlitz, 2013b) the foundations regarding healthcare service quality and healthcare service network have been published. The difficulties of operationalizing productivity and service quality along the complete patient care pathway and the characteristics of healthcare service network as described in Chapter 2 are outlined in these papers. Thus, they partly reflect the theoretical contribution of Part I.

Based on the implications of Part I, the coordinating service has been engineered and the prototype's development and evaluation have been published at international conferences, in one international journal, and in a book chapter. The gathered requirements of the central, coordinating service regarding process and IT-architecture have been published at the European Conference on Information Systems ECIS 2012 (Görlitz and Rashid, 2012b). They have then been reviewed, extended by legal requirements and been published in the Journal Health Policy and Technology (Görlitz et al., 2012). Since the service development followed an evolutionary prototyping approach, new insights regarding the stroke manager service were gathered between the two publications. Due to the fact that health data is viewed as the most vulnerable data available, the provided data security concepts were presented at the German Conference for Medical Informatics, Biometry, and Epidemiology (GMDS) (Görlitz and Rashid, 2012a). Additionally, findings with respect to purely technical issues and how the system applies to current medical practice have been published at the eHealth Conference 2012 in Vienna, Austria (Görlitz et al., 2012). The findings regarding the individual support of stroke patients with mobile technology have been presented on the eLearn Conference 2012 in Montréal, Canada (Görlitz and Görlitz, 2012). Furthermore, the ideas of the mHealth developments have been presented at the Medicine 2.0 in London, UK (Görlitz and Hagedorn, 2013). More practical implications of the validation in Part II and the evaluation in Part III have been published in a book chapter about inter-organizational coordination concepts in Germany (Görlitz, 2013a). Since the stroke manager service was in practice for more than 18 months to gather the necessary data for a sound evaluation, the full-standing results that are presented in this thesis in Part III have

²In the BMBF-funded project easyCare, different means to support care-giving relatives were identified and evaluated. For more details refer to <http://www.projekt-easycare.de/>.

not been published elsewhere. Preliminary results have been presented at the AAL Kongress 2013 in Berlin, Germany (Görlitz et al., 2013). Insights regarding the coordination service's effectiveness, efficiency, and acceptance that have been drawn from the complete data sets of 105 patients are not published yet. Complementary research regarding the possible healthcare-related utilization of telemedicine devices in the quantified self movement has been studied and presented at International Conference on Information Systems 2013 (Gimpel et al., 2013).

Beyond that, between 2010 and 2013, the research on the coordination in a healthcare service network and the Stroke Manager Service was contributed and reviewed within the INSPIRE project initiated by the German Federal Ministry of Education and Research³. As motivated before, healthcare systems in most countries, particularly in Germany, lack coordination between independent healthcare organizations. Especially the pre-clinical and post-acute transition between emergency services, hospital, and outpatient service providers lacks coordination. The rationale behind the INSPIRE project is the difficulty of measuring quality and productivity in the healthcare domain with several independent stakeholders involved. In the project, the two identified transition problems are investigated exemplarily for stroke within the two case studies Stroke Angel for the pre-clinical transition and Stroke Manager for post-acute transition. Whereas Stroke Angel is already fully implemented and used by several emergency services in Germany to improve the information exchange with the hospital on regular basis, the Stroke Manager was completely designed anew. Since the processes and ICT-structure of the Stroke Manager service were newly designed, the research project also evaluated its feasibility and acceptance apart from investigating the stroke manager service's impact on coordination in the regional network of independent healthcare service providers.

³In the INSPIRE project (November 2010 until October 2013), researchers and practitioners investigated the question of how to measure and improve stroke patient care from November 2010 until October 2013. For this purpose instruments of service science, organizational theory, information management, and medicine were used to realize innovations in the healthcare sector. For more details refer to <http://www.inspire-healthcare.de/>.

Chapter 2

Towards Healthcare Service Networks

This chapter's objective is to give a detailed introduction to the application scenario of the work at hand while presenting the necessary fundamentals. As motivated in Section 1, the work at hand investigates how to improve coordination in inter-organizational healthcare settings. In detail, it deals with a service-oriented approach that aims at improving healthcare service quality (HSQ) in a healthcare service network (HSN) by facilitating information flow between stakeholders of the healthcare service network. It is therefore important to thoroughly discuss and define HSQ, HSN, coordination, information management, and related concepts in inter-organizational settings. This chapter presents the fundamentals of healthcare services, healthcare networks, and inter-organizational coordination. In doing so, it addresses Research Question 1, which investigates how to operationalize coordination in a network of independent stakeholders in order to assess its quality – particularly in healthcare settings.

Section 2.1 provides fundamentals about healthcare. It defines healthcare services while highlighting differences to the common understanding of services. Following basic healthcare service definitions, service quality is discussed in the context of healthcare. Here, a framework for measuring service quality along the complete patient care pathway is presented, which is important for patients suffering from chronic conditions. In Section 2.2, general concepts of inter-organizational networks in healthcare are discussed. After introducing healthcare networks and their various definitions, concepts of business networks are presented. Subsequently, healthcare service networks (HSNs) are introduced as a network of independent healthcare stakeholders, which combine aspects of business networks and supply chains with a more service-oriented view. In Section 2.3, state-of-the-art literature regarding coordination in inter-organizational settings is discussed. Here, inter-organizational coordination is described from economic and information system perspective. Fur-

thermore, coordination is related to information flow and information management in inter-organizational settings.

By presenting healthcare fundamentals, this chapter provides a basis for the work at hand with respect to notions such as like healthcare service, quality, inter-organizational healthcare networks, and business networks. In addition to presenting necessary fundamentals, this chapter contributes a definition of the HSN concept and its differentiation from related network types. It focuses on aspects of coordinating independent healthcare stakeholders in such a setting and highlights the importance of information flow as well as network's service quality. After introducing healthcare fundamentals, this chapter particularly highlights related work in the cross-section of organizational theory, information systems, and service science while providing an overview of the large corpus of related work in this research area.

2.1 Healthcare Fundamentals

In the last decades, services' share on the gross domestic product (GDP) has increased dramatically and they make up the largest part in industrialized countries (Wölfl, 2005). At the same time, since the 1990s, the service sector is the only sector in industrialized countries that provides growth in terms of GDP¹ and employment (Wölfl, 2005). In 2012, the service sector's share of GDP amounted to 73.4 in the EU, 71.1% in Germany, and 79,7% in the USA². The healthcare sector has traditionally been service-driven, and is one of the fastest growing areas in service economy (Andaleeb, 2001). Recent analysis of the Worldbank from 2012 explicitly stated the healthcare related percentages of the GDP in 2010: 9.0% for the EU, 11.6% for Germany, and 17.9% for the USA (WorldBank, 2012).

Healthcare services in general have a long history of being underused, misused, or overused simultaneously (Johnston, 2004; Ovretveit, 2011). Underuse of effective care takes place when involved stakeholders neglect to provide medically necessary care or do not follow proven healthcare practices. Underuse can be triggered on healthcare service provider side, for example by not prescribing appropriate rehabilitation services. It can also be triggered on patient side if the prescribed rehabilitation is not pursued regularly. On the one hand, this is caused by discontinuity of care, i.e. missing information flow between involved stakeholders along the patient care pathway. On the other hand, underuse is caused by fast development and slow uptake of novel medical guidelines: the physician might simply not know that

¹<https://www.imf.org/external/ns/cs.aspx?id=28> (last accessed December 2013)

²<https://www.cia.gov/library/publications/the-world-factbook/fields/2012.html> (last accessed December 2013)

there is a better drug that should be prescribed even though the involved stakeholders communicated sufficiently. Misuse is another way of describing avoidable errors in a situation in which there are significant tradeoffs among the available options (Ovretveit, 2011). Its causes are somewhat similar to underuse – for example prescribing a rehabilitation service a patient cannot take fully advantage of while there is a likewise effective treatment for the patient. Overuse occurs when a drug or treatment is given without adequate medical justification because more is not always better. It is particularly apparent in supply-sensitive care – for example admitting patients with chronic conditions to hospitals instead of treating them as outpatients when there are free capacities. Another example is, prescribing imaging exams, such as MRIs, that do not change the patient’s treatment.

This inadequate use is partially rooted in the unique healthcare setting, in which there is a triangular relationship between service providers, service consumers, and service payers (Figure 2.1). Albeit the countries’ individual differences regarding the specific design, all western healthcare systems have this distinct triangular relationship between service providers, service consumers, and service payers in common. Furthermore, three quarters of western countries’ health spending are publicly financed (Johnston, 2004). This implies that – in contrast to other domains – political entities and government agencies have a strong influence in the healthcare system. Even in the USA, which traditionally do not require their people to have a health insurance, a majority has basic insurance and with Obama’s recent Medicaid expansion even more will be (Iglehart, 2011). Consequently, even in a country with one of the most individual, pay-for-performance health system of western countries, patients are rather service consumers than customers. Health insurance act as service payers. Therefore, many concepts from other domains cannot easily be applied.

Even though single stakeholders might benefit from constricted information flow, missing coordination between healthcare service providers leads to unfavorable situations for all three groups: service providers, service payers, and service consumers. For service providers, service underuse means suboptimal or even absent usage of their healthcare services, which results in less revenue. For service payers, service overuse results in unreasonably high costs. Furthermore, overuse and underuse deprive them of reliable healthcare service utilization prognosis and control. For service consumers, patients, healthcare services overuse, underuse, or misuse disturbs their optimal recovery and decreases compliance regarding healthcare treatment. Since the work at hand investigates processes and structures necessary for care coordination, it focuses on actively involved stakeholders, i.e. service consumers and service providers. The service payers are only considered subordnately. For a deeper understanding of the setting, healthcare services are defined and quality of healthcare is investigated in the next subsections.

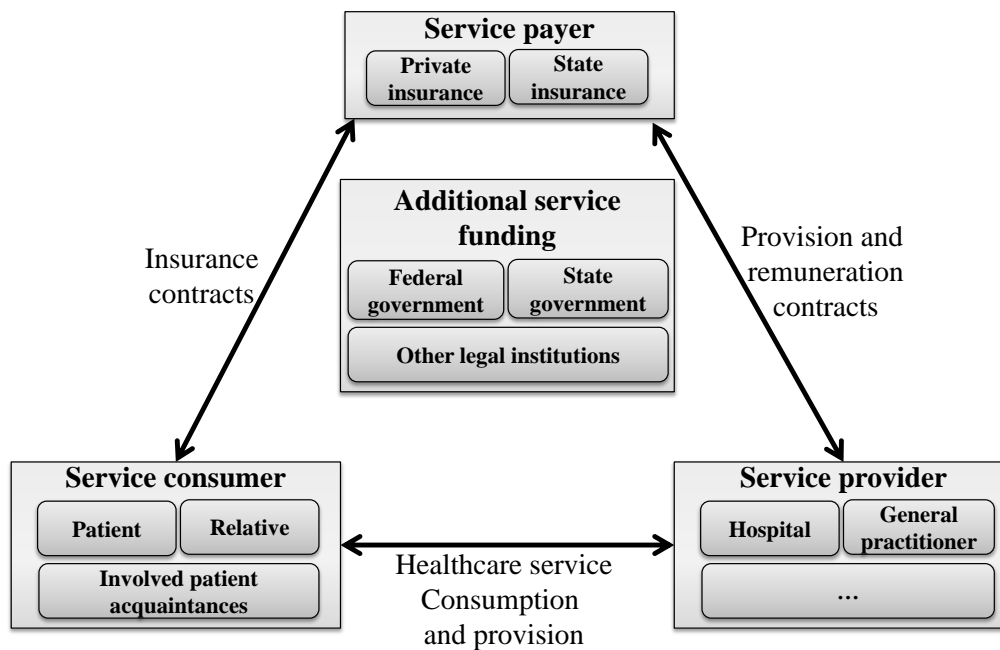


Figure 2.1: Simplified illustration of the relationships between the major stakeholder groups in the healthcare system

2.1.1 Healthcare Services

In spite of the large body of contributions to literature, a common definition of what a service actually is, has yet not been agreed upon. There are entirely different philosophies behind different service definitions from different research fields (see for example (Hill, 1977; Lovelock, 1983; Scheuing and Johnson, 1989; Edvardsson and Olsson, 1996; Vargo and Lusch, 2004; Grönroos and Ojasalo, 2004; Spohrer et al., 2007; Bullinger and Schreiner, 2003; Menschner and Leimeister, 2012; Leimeister, 2012)). A general service description is provided by the "IHIP" paradigm, even though it has been challenged by and does not provide a comprehensive service definition (Vargo and Lusch, 2004). The paradigm states that services' main characteristics are intangibility, heterogeneity, inseparability of production and consumption, and perishability. Services are mostly physically *intangible* and incapable of being perceived by senses. Usually, services' outcomes or processes are very difficult to standardize. This *heterogeneity* induces a variability in "individual units of service" that also might be judged individually by different customers. Services are produced and consumed simultaneously, which – in contrast to resources and services' input – makes it impossible to store the output of the service process. This *Inseparability* of production and consumption are rooted in the general service delivery process, which cannot begin until customer input or customers themselves are available. Services are also characterized by *perishability* because providers' capacity to deliver the service is only available at a certain point of time, i.e. services

cannot be stored. In addition to the IHIP characteristics, customers are often active participants during service delivery acting as *co-producer*. Variability and simultaneous production and consummation with customer participation often leads to *labor-intensity* of services.

As stated above, these basic characteristics are not agreed upon. The general "IHIP" paradigm – intangibility, heterogeneity, inseparability of production and consumption, and perishability – has been challenged (Vargo and Lusch, 2004). For example, Vargo and Lusch (2004) argues that services produce tangible outputs that might be "sensed" (e.g. surgery), that their heterogeneity can also be standardized by automation, and that some services are not produced apart from the customer (e.g. transports). Even though this is an interesting academic research area, finding an adequate service definition including product delineation is not desired in this work. Hence, the used service definition is based on one of the most widely accepted general service definitions that was formulated by Hill (1977):

Definition 2.1 [SERVICE]. *A service can generally be described as condition change of a person or good resulting from an economic unit's activity that has been approved by the person or economic unit owning the good (Hill, 1977).*

This general service definition does not describe healthcare services adequately (Berry and Bendapudi, 2007). First of all, not all healthcare services are necessarily wanted by patients. This leads rare but occurring occasions that services are performed without being approved by the person it is performed for. Furthermore, patients usually act as *co-producer* because they directly or at least indirectly participate during service creation. For example, during rehabilitation or therapies that involve patients' compliance, their behavior directly influences the outcome independent of healthcare service providers. Even for services that happen somewhat independent of the patient, e.g. surgery with anesthesia, their previous behavior indirectly contributes to the outcome. As stated by Berry and Bendapudi (2007), healthcare services have six further distinguishing characteristics regarding customer and provider. They are enumerated and summarized in the following:

1. **"Costumers are sick"**. This leads to a high stress level and costumers that sometimes "live" in the place where the service is performed. Stress-induced anxiety has been proved to enforce risk-aversion and living where the service is performed narrows the costumers' choice: They cannot come and go at will.
2. **"Costumers are reluctant"**. When it comes to surgical procedures or annual checkup exams, costumers often approach a healthcare service reluctantly. In rare occasions, they do not want the healthcare service. This affects their ser-

vice quality perception and even their degree of co-production. Especially the latter is often neglected by service scholars.

3. **"Costumers relinquish privacy"**. Customers constantly have to reveal intimate details of their lives to receive the best possible service.
4. **"Costumers need a 'whole person' service"**. This requires an individual fit regarding the customer's medical condition, age, mental condition, personal traits, family circumstances, financial capacity, and much more.
5. **"Costumers are at risk"**. There is always a considerable percentage that the service will not only fail to provide expected results, e.g. restored health, but additionally have further negative effects.
6. **"Healthcare service providers are afflicted emotionally"**. Providing services for ill people is emotionally and physically stressful.

Apart from the above stated differences, healthcare services always have some sort of ethical perspective independent of service provider and costumer. Besides being labor-intensive, healthcare services are also traditionally knowledge-intensive. Especially in the healthcare domain, there is a high degree of organizational differentiation and specialization. This induces a limit to the possible service automation level and process standardization. Based on these characteristics and Definition 2.1, a healthcare service can be defined as follows.

Definition 2.2 [HEALTHCARE SERVICE]. *A healthcare service is a knowledge-intensive, labor-intensive, and potentially harmful service with an ethical perspective that heavily depends on sick – sometimes even reluctant – customers as co-producers having to relinquish their privacy. In addition, providers of healthcare services are often emotionally stressed during service performance.*

After defining healthcare services and delineating their differences to the "general" service conception, the next section deals with service quality – mainly, how to define and measure service quality, particularly in inter-organizational settings.

2.1.2 Healthcare Service Quality

Similar to services, healthcare service network (HSQ) is a very ambiguous term and has been discussed for decades, but a common understanding has not been achieved (see Donabedian (1966, 1988); Berry and Bendapudi (2007); Porter and Olmstead Teisberg (2006); Kaplan and Porter (2011); Andaleeb (2001); Hiidenhovi et al. (2002); Wisniewski and Wisniewski (2005); Yun and Chun (2008) for various definitions).

Missing common understanding is partly rooted in different perspectives on HSQ such as healthcare service providers, the society, the individual patient, and insurances. Donabedian (1966) compiles various approaches and methods for evaluating the quality of medical care stating that "quality lies in the eye of the observer" and that there are two distinguishing perspectives of efficiency: The logical and the economic perspective. The former involves ethical factors, such as allowing the population efficient access to all available healthcare services. The later takes the perspective of economically optimal distribution of the available healthcare services which might involve rationing, e.g. denying patients a potentially advantageous service. Donabedian continued to postulate seven pillars of healthcare quality including efficacy, effectiveness, efficiency, optimality, acceptability, legitimacy, and equity (Donabedian, 1990). More important than actual healthcare quality determinants is Donabedian's comprehensive remark that their weight depends on the observer, thus healthcare service quality depends on the perspective.

Apart from perspectives, there are two challenges when measuring quality of healthcare services for patients. First, quality of every service is difficult to measure objectively because it does not solely depend on results but also on individual perception and customers' comparison with individual expectations (Parasuraman et al., 1985; Edvardsson and Olsson, 1996). When measuring healthcare service quality, the impact of this individual perception is even greater (Berry and Bendapudi, 2007). Due to the service's knowledge-intensive nature as described in Section 2.1.1, the patient cannot fully judge the service's quality because of missing medical knowledge. Moreover, since customers of healthcare services can be reluctant (Section 2.1.1), a healthcare service can be of good quality, but the patient judges it poorly because it was unwanted. The second challenge relates to the fact that patients are not necessarily the "customers" of a healthcare service, but more "consumers." They rarely pay for received service because health plans or other forms of insurance companies handle it for them. Sometimes, they are even restricted in their service choice because they are referred to by a general physician or the health organization that pays the medical bill determines the available service providers.

Because of these two challenges, existing and validated approaches from service science literature that measure service quality – such as GAP analysis (Parasuraman et al., 1985), SERVQUAL (Parasuraman et al., 1988), KANO (Kano et al., 1984), or the critical incident technique (CIT) (Gremler, 2004) – cannot be applied easily in the healthcare domain (Dean, 1999; Feinstein, 2002). They are all purely based on customer service satisfaction but as patients are more consumer than customer and, moreover, they might not be able to choose the service provider freely, their perception of the service is not necessarily the decisive factor for quality. Yet, the healthcare industry starts to do investigate the impact of patient satisfaction on their business as competition has been growing in the past decades. Thus, these customer-centered

approaches have been adapted and used for measuring HSQ from an organizational point of view (Li, 1997; Dean, 1999; Andaleeb, 2001; Hiidenhovi et al., 2002; Wisniewski and Wisniewski, 2005; Yun and Chun, 2008). These approaches put their focus on costumer-centered key-determinants such as physician empathy, amount of attention to patients, building layout, hygiene, or professionalism indicated by staff's skills, experience, or innovation (Dagger and Sweeney, 2006; Büyüközkan et al., 2011).

However, these approaches only measure individual performance of a single stakeholder, which does not reflect joint quality of healthcare stakeholders that act in a network. Improving individual service quality does not necessarily improve the network's quality. For example, Olivera Marjanovic (2011) reports that improving healthcare process efficiency in terms of business process improvement in an insulated hospital environment, does not necessarily improve quality of patient care along the complete patient care pathway (Olivera Marjanovic, 2011). To capture all effects along the complete patient care pathway, this work takes a network perspective on healthcare service quality as described by the recent OECD healthcare report (Hofmarcher et al., 2007). The commonly accepted healthcare service research view is applied, which adopts division of healthcare service quality into *structure*, *process*, and *outcome* (Donabedian, 1966, 1988) as shown in Figure 2.2. Donabedian also stated that each part is interdependent and that structures influence processes and, in turn, processes influence outcomes (Donabedian, 1966).

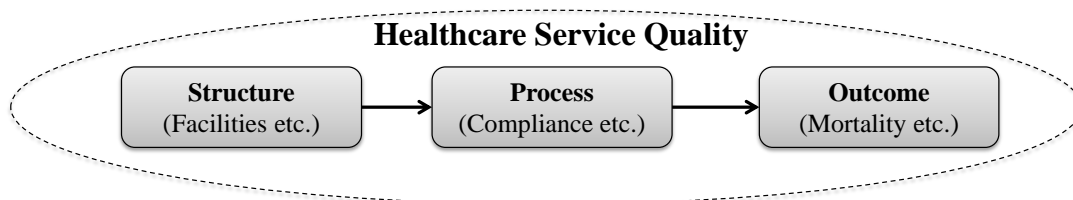


Figure 2.2: Illustration of healthcare service quality's constructs according to Donabedian (1988)

This is similar to the classification in service science, where *potential*, *process* and *outcome* are often differentiated (Engelhardt et al., 1993; Meyer and R, 1987). *Structure* or *potential* relates to resources that contribute to the ability to meet healthcare needs of the population, i.e. good care settings and supporting structures. This includes adequate facilities ,equipment, and qualification of care providers. *Process* examines what is done for patients and how well it is done, i.e. compliance with recommended practice regarding appropriateness, acceptability, completeness, and competency. *Outcome* refers to patients' state of health resulting from their interaction with healthcare providers. Outcomes such as mortality rates, improvements of functional abilities, or morbidity are usually precisely measured. Other outcomes

such as patient lifestyle improvements, attitudes or satisfaction cannot be precisely measured. In contrast to the service domain, in which customer perception is often the sole measure for service quality (see Parasuraman et al. (1988); Kano et al. (1984); Ramaswamy (1996); Shostack (1982); Bullinger and Scheer (2006)), it is still unclear if it really is a relevant outcome measure in healthcare (Chow et al., 2009).

This description of HSQ was originally introduced by Donabedian to assess quality of care in clinical practice. Since it does not have any implicit definitions it can be applied to various fields and is widely recognized in healthcare service research (Meyer and R, 1987). However, the limited inclusion of antecedent parameters such as patients' cultural, social, physical and personal characteristics or other environmental factors is criticized (Coyle and Battles, 1999). Therefore, the HSQ description only serves as a touchstone framework to operationalize HSQ, which is addressed by Research Question 2. Each of its three constructs is made up of different, independent dimensions that need to be defined for each scenario individually in order to operationalize HSQ. Furthermore, according to Donabedian (1988) information about "causal linkage" between the three dimensions is needed.

Because of the service-oriented approach and the unknown causal linkage between the interdependent features of *structure* and *process*, these two features are jointly investigated as healthcare delivery quality. Therefore, for the work at hand, HSQ is composed of healthcare delivery quality and patient health. In doing so, the original definition of Donabedian (1988) is adapted accordingly.

Definition 2.3 [HEALTHCARE SERVICE QUALITY (HSQ)]. *Healthcare service quality (HSQ) is a property of one or a bundle of healthcare services that is provided by one or multiple organizations. It serves as a conceptual framework for examining healthcare services and evaluating quality of care that is provided to individual patients along the complete care pathway. This framework includes the two distinct components healthcare delivery quality and patient health, which are both based on structure, process, and outcome (cp. Donabedian (1988)).*

This definition of HSQ addresses the complete patient care pathway from onset of a disease until complete convalescence or death. For chronic diseases, a patient-centered view that is independent of the involved healthcare stakeholders is necessary for capturing HSQ from a network perspective (Berwick, 2009). However, like the ambiguous definitions of HSQ, definitions of patient-centered healthcare are also rather vague (see for example (Li, 1997; Dean, 1999; Andaleeb, 2001; Anderson and Knickman, 2001; Haux, 2006; Bodenheimer, 2008; Yun and Chun, 2008; Berwick, 2009; Winter, 2009; Gianchandani, 2011; Kaplan and Porter, 2011; Wilson et al., 2012)). For the work at hand, the definition of patient-centered healthcare fol-

lows the prevalent view of the IS community that tries to exploit ICT to improve patient empowerment and patient activity while providing the involved healthcare providers with timely information.

Definition 2.4 [PATIENT-CENTERED HEALTHCARE]. *Patient-centered healthcare is an approach to healthcare that focuses on the patient along the complete patient care pathway, i.e. from onset of a disease until complete convalescence or death.*

In contrast to traditional forms of care delivery, which are professionally dominated and rather focus on healthcare providers, patient-centered healthcare puts an emphasis on patient empowerment, increases patient activity, and aims at shifting more control into patients' hands (cp. Haux (2006); Berwick (2009); Wilson et al. (2012); Sun et al. (2013)). In line with Definition 2.4, measuring **healthcare delivery quality** in a network of independent healthcare stakeholders goes beyond internal process compliance (Olivera Marjanovic, 2011) or the available ICT-structure (Newell et al., 2013). To achieve **high healthcare delivery quality**, competences and knowledge of the involved stakeholders – in a patient-centered approach, particularly patient competences – play a vital role (Bodenheimer, 2008). Patient self-management competences in the whole process of care delivery are important because the patient is a co-producer (Sun et al., 2013). They are primarily influenced by amount and form of information provided to patients about their disease (Bodenheimer et al., 2002; Wilson et al., 2012). This includes knowledge about the disease itself or available healthcare services for treating their disease, secondary prevention (adequate diet, physician-directed behavior etc.), and adherence (regular physician visits, taking the prescribed medication etc.). The more patients know about their disease, the better is their influence on HSQ (Langhorne and Duncan, 2001; Bodenheimer, 2008). Furthermore, timely and adequate utilization of available services according to current medical guidelines also increase the healthcare delivery quality, hence HSQ of the network (Donabedian, 1988; Bodenheimer et al., 2002; Keyhani et al., 2012). Although there are several metrics that measure quality of processes and structures, e.g. delay between different rehabilitation phases, utilization of outpatient services, or discharge preparation, there are no general metrics that are sufficiently detailed (Donabedian, 1988). For example, it is highly disease-specific what outpatient services a patient should take advantage of. Thus, metrics for healthcare delivery quality have to be identified and evaluated case-dependent for the coordination service.

The **patient health, i.e. the outcome, has two dimensions**: Final patient outcome and intermediate patient outcome (Donabedian, 1988; Kjellström et al., 2007). Final patient outcomes are unique indicators for patient health, e.g. mortality and life expectancy. Intermediate outcomes indicate effectiveness of certain treatments,

which aim at improving final patient outcome. They are proxies for final patient outcomes, e.g. physiologic values, such as blood pressure, or scores on medical scales. Particularly, non-motor skills have been shown to have an impact on health-related quality of life and therefore, need to be considered (Haacke et al., 2006).

2.2 Inter-organizational Healthcare Networks

This section specifies research approaches which are closely related to the investigated research questions and highlights their issues and shortcomings. When investigating inter-organizational networks in healthcare, the focus of the analysis is put on relationship between organizations with the goal to increase efficiency and effectiveness of the complete network. Even though there are different network definitions depending on the research discipline, a network is commonly described as a set of edges and vertices (Malone and Crowston, 1994; Sydow and Windeler, 1998; Goodwin et al., 2004; Provan et al., 2007). Since this work investigates a coordination service between different stakeholders, which are mostly different organizations, networks are defined according to organizational theory as follows.

Definition 2.5 [NETWORK]. *A network is a finite number of stakeholders linked through multilateral ties in a way that facilitates achieving a common goal. The relationships among the network stakeholders is primarily non-hierarchical, and the connections may be informal, e.g. totally based on trust, or formal, e.g. through a contract (Sydow and Windeler, 1998).*

Albeit Definition 2.5 is commonly accepted, the interpretation of edges and vertices may vary massively according to different domains and applications (Provan et al., 2007). Nevertheless, this approach has been shown to be particularly effective in describing structure and dynamics of socio-economic networks, i.e. networks in which economic activities and social ties are taken into account (Brandes et al., 2001). It has been argued by many scientists from different research fields that the healthcare industry has features that differ from other industries³ (Arrow, 1963; Mooney and Ryan, 1993; Berry and Bendapudi, 2007; Smith et al., 2008; Winter, 2009; Mäenpää et al., 2009; Thrasher et al., 2010): healthcare services have different characteristics and there are inherent structural problems such as strong positive externalities and high levels of uncertainties. This section discusses different healthcare network definitions and relates it to more general concepts of business networks or service networks in the first two subsections. Ensuing, the concept of a healthcare service network describing a network of independent stakeholders along the patient care pathway is introduced in the following subsections.

³Refer to Section 2.1.1 for more details.

2.2.1 Healthcare Networks in General

There are several healthcare-specific definitions of a socio-economic network in the literature of service science, organizational theory, and information systems. An excerpt of most commonly used definitions is accumulated in Table 2.1. This excerpt does not constitute an exhaustive compilation, yet, it highlights the definitions' variety. Especially since many papers that deal with healthcare networks are not listed because they do not necessarily define them. Numerous publications aim at improving quality, effectiveness or efficiency of health networks without defining the network structures precisely (see for example (Li, 1997; Dean, 1999; Wisniewski and Wisniewski, 2005)). As illustrated in Table 2.1, the only consistency in the available definitions is independence of different stakeholders and the networks's goals.

Since there is no common definition, the general network definition (Definition 2.5) is used as a basis. To delineate existing network concepts, Goodwin et al. (2004) "conceptual continuum of network forms in health care" is used, which is illustrated in Figure 2.3. It constitutes a measure for the "organization" level of the network regarding its management centrality, resource control, and organizational complexity. The *informational network* focuses on the exchange of information and knowledge, i.e. developing evidence-based medical guidelines or guidance support for the network's participants. In *coordinated networks* new forms of cooperation are developed and implemented, e.g. new inter-organizational clinical pathways. Here, the stakeholders are still independent regarding financial and medical responsibilities. *Procurement networks* add contracts between stakeholders to allow better coordination and commitment. In *managed networks* stakeholders do not only have sophisticated contracts to coordinate healthcare services, but payment is also based on fixed rates regarding patient case mix. Its distribution is done by a central management unit making this kind of healthcare network similar to a hierarchically constituted organization itself.

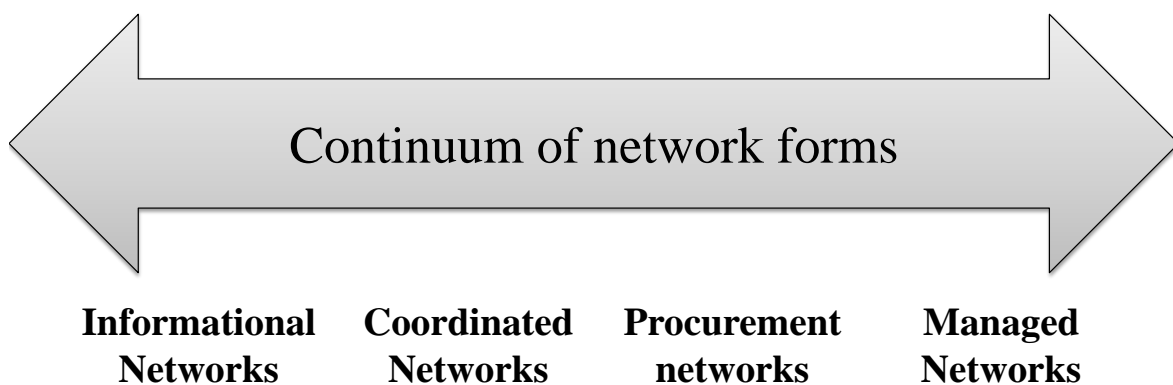


Figure 2.3: Network forms in healthcare as defined by Goodwin et al. (2004)

Term	Definition
Healthcare Network or Health Care Network	<p>A healthcare network is a network of providers that are organized as gatekeeper network with central authority (Schicker et al., 2008).</p> <p>A health care network is a complex network organization in which autonomous entities [...] collaborate to achieve a global objective (Kartseva et al., 2010).</p> <p>A health care network is characterized by mutual dependencies, complex goal systems and non-hierarchical governance forms (Hellrung et al., 2008).</p>
Health Network	<p>A health network consists of autonomous units that have joined together to achieve a common purpose. [...] Trust, commitment and interdependence form the glue of collective action rather than ownership (Alexander et al., 2003).</p> <p>A health network is defined as formalized cooperation between independent health care providers (Meijboom et al., 2004).</p>
Healthcare Service Delivery Network	<p>Healthcare service delivery network is a group of three or more autonomous organizations working together across structural, temporal and geographic boundaries to implement a shared population health or health service strategy (Huerta et al., 2006).</p>
Strategic Healthcare Alliance	<p>Strategic healthcare alliances are clusters of two or more organizations that make decisions jointly, integrate their efforts and contractually pool resources to provide a service and achieve a long-term strategic purpose that is not possible for a single organization (Thrasher et al., 2010).</p>
Health Service Network	<p>A health service network is a network of health maintenance organizations (HMOs) and health care providers, such as general practitioners and specialty physicians (Hammerschmidt et al., 2012).</p>

Table 2.1: Selected definitions of inter-organizational networks in healthcare.

In the literature, most of the discussed healthcare networks are *coordinated*, *procurement*, or *managed networks*, in which either sophisticated contracts between the involved stakeholders exist (Meijboom et al., 2004; Schicker et al., 2008; Blechmann et al., 2012) or an organizational core is granted the authority to regulate all stakeholders' work – virtually forming another organization (Page, 2003; Hellrung et al., 2008; Thrasher et al., 2010; Hammerschmidt et al., 2012; Gusew et al., 2012). In these networks, prevailing concepts of coordination are standardization and hierarchical power can be assured. State-of-the-art literature does not investigate *informational networks* in which stakeholders only share information and knowledge without agreed upon standardized processes and sophisticated contracts have not been investigated.

When looking at the complete patient care pathway, which ranges from diagnoses and first acute treatment to regular outpatient care, rehabilitation, long-time medication, and required life-style changes, the involved stakeholders form an *informational network*. Unless there is trust between stakeholders, they often do not even form an *informational network* as described by Goodwin et al. (2004), because they do not necessarily share information even if it was beneficial for them. They rather form a network of healthcare service providers that perform complementary services for patients suffering from a chronic disease, e.g. acute treatment like surgery and therapeutic measures like vocational training. Furthermore, all introduced concepts of inter-organizational healthcare networks focus on healthcare service providers. Thus, patients are not explicitly included in these inter-organizational coordination considerations even though as "co-producer" they have a major impact on HSQ (Section 2.1.1). Therefore, a definition of loosely connected stakeholders in healthcare is needed that includes a patient-centered and a service-oriented view of healthcare services provided along the complete patient care pathway. Before such a network concept will be introduced in Section 2.2.3, economic fundamentals that are necessary for this description are presented in the next subsection. It discusses existing network concepts and their features.

2.2.2 Business Networks and Service Networks

Extending the general network definition (Definition 2.5) to healthcare, inter-organizational healthcare networks can be described as two or more economic entities, i.e. healthcare stakeholders, that cooperate to achieve a common goal. Due to the Hippocratic Oath by which physicians and other healthcare professionals swear to practice medicine ethically and honestly, the assumption holds that – among various individual goals or even other shared goals – involved healthcare stakeholders have the common goal to increase the patients' health quality (Mooney and Ryan,

1993). The healthcare stakeholders such as healthcare service providers and even patients themselves contribute to the network's common goal stepwise by providing individual services. From this perspective, they form a service network along the complete patient care pathway with the stakeholders providing services to increase patients' health quality, i.e. patient value.

From an inter-organizational perspective, the stakeholders in healthcare networks can be described as a business network. In the business network, the stakeholders have voluntary and rather flexible relationships to collaboratively create (business) value (Siebert, 2006).

Definition 2.6 [BUSINESS NETWORK (BN)]. *A business network (BN) constitutes the most general form of economically motivated cooperation among different legal entities (Holm Blankenburg et al., 1996).*

The major goal of a business network is to increase business value. However, achieving this goal does not imply increasing patient value. Healthcare providers generally do not compete for patient value because the provider offering the best quality does not get rewarded nor do weaker providers go out of business (Porter and Olmstead Teisberg, 2006; Kaplan and Porter, 2011). Porter points out that in healthcare there is "the wrong kind of competition" (Porter and Olmstead Teisberg, 2006). Healthcare service providers compete in insulated parts of the patient care pathway and their gains come at the expenses of other stakeholders, they are not competing with (Kaplan and Porter, 2011). For example, hospitals do not get paid by the quality of care they provide, but rather by the amount of patients they "serve." Thus, they streamline their internal processes to decrease patient cycle time in the hospital. This in turn might lead to additional work for post-acute healthcare service providers like ambulatory services that they cannot charge the hospital for. Existing incentives do not facilitate individual cooperation between healthcare service providers from different stages of the healthcare value chain along the patient care pathway, e.g. clinics and ambulatory service providers (Kaplan and Porter, 2011). On the one hand, individual healthcare service providers like general practitioners (GP) usually only form small, regional networks with other GPs. On the other hand, cooperation along the healthcare value chain requires a large organization: Either regionally strong hospitals that provide the platform for cooperation with other regional stakeholders or health maintenance organizations that introduce an integrated care system.

All approaches regarding business networks in inter-organizational healthcare settings have in common that they merely consider patients as customer (Kaplan and Porter, 2011). They try to create business value without taking into account

what impact patients have as co-producer⁴. Furthermore, they do not capture the loose coupling of healthcare stakeholders involved along the complete patient pathway. A more service-oriented approach to networks in healthcare promises to solve both disadvantages of existing approaches. Business network approaches' missing patient-centering along the complete patient care pathway is compensated for in the field of service science. Here, service provider and service consumer are taken into account when looking at the value created (Vargo and Lusch, 2004). In service science literature, these networks are called service networks (Razo-Zapata et al., 2012) or service systems (Tien and Goldschmidt-Clermont, 2009).

Definition 2.7 [SERVICE NETWORK]. *A service network (SN) is a number of individual stakeholders who establish relationships among themselves to provide a specific service (cp. Razo-Zapata et al. (2012)).*

Service networks are basically (smart) business networks (Basole and Rouse, 2008). According to Gaur et al. (2005), they can be differentiated into four stages:

1. The first stage is characterized by various organizations "providing basic services and meeting, probably, only part requirements of the customers."
2. In the second stage, organizations still provide their services independently, but "there are informal agreements for sharing of services."
3. The third stage is the beginning of coordination between providers to minimize "overlapping services, reduce duplicate processes and share resources." This stage "usually necessitates an external coordinator" and formal agreement amongst the service providers.
4. The fourth and final stage is described as "a totally integrated service network," in which boundaries between providers are supposed to vanish completely. Though, according to Gaur et al. (2005) this final stage has not been achieved by any industry or existing network.

These stage descriptions have been adopted and extended by Basole and Rouse (2008) to describe their idea of service value networks. In contrast to the definition by Gaur et al. (2005), in their model even the first stage of a service network relies on the information technology, e.g. the internet, to allow sharing of information. Even though Gaur et al. (2005) and Basole and Rouse (2008) describe service networks, both definitions are difficult to apply to the healthcare domain. Since they are based on a business network approach, they cannot easily incorporate patients as co-producer of the service quality in the network, which is a prerequisite when

⁴Refer to Section 2.1.1 for more details about patients as co-producers.

taking a patient-centered approach. Especially patients suffering from chronic diseases do not merely "consume" a healthcare service, but rather act as co-producers. For changing traditional communication channels to a more patient-centered view, stakeholders in a network cannot be differentiated by service provider and service consumer as existing service network concepts do (Hammerschmidt et al., 2012). Moreover, it can be observed that studies which incorporate both information technology aspects and organizational aspects highlight the complexity of the research area. Therefore, an inter-organizational network approach that incorporates the different perspectives as well as the technical and organizational level is needed (Payton et al., 2011). Otherwise, improvements in structure and process along the complete patient care pathway that have inter-organizational effects cannot be measured and thus evaluated appropriately.

2.2.3 General Healthcare Service Network

As described in the previous paragraphs, existing network concepts do not capture the loosely connected stakeholders along the complete patient care pathway. Current approaches only focus on insulated parts of the patient care pathway, and general network concepts cannot easily be transferred (Hammerschmidt et al., 2012). Especially for patients suffering from chronic diseases, long-term effects are important and should be taken into account. Measuring short-term effects, such as process compliance, is not expedient. Therefore, the concept of healthcare service networks (HSNs) is introduced. They are a form of service networks accounting for domain-specific healthcare service characteristics. Extending Definition 2.5 and Definition 2.7, which define general networks and service networks, respectively, a healthcare service network is defined as follows.

Definition 2.8 [HEALTHCARE SERVICE NETWORK]. *A healthcare service network (HSN) is a finite number of individual stakeholders linked through multilateral ties, i.e. information flow, to facilitate performing interdependent healthcare services along the patient care pathway.*

Like every service network, HSNs describe cooperation between entities that can be individuals or organizations. Unlike current perception of service value networks Basole and Rouse (2008), entities are not necessarily connected via the internet. This assumption does not capture real world conditions because there might be stakeholders along the patient care pathway that are not online, e.g. many therapists. As business networks, information flow plays an important role in healthcare service network, and is the key to coordinated processes. The members of an HSN cooperate and compete at the same time, but in comparison to other networks, they do

not necessarily have to share information. Simply the possibility of sharing valuable information and acting on behalf of the patient makes a healthcare service provider part of the HSN. Otherwise, the holistic approach is not satisfied. Therefore, HSN members are not necessarily committed to the network's success, albeit in healthcare stakeholders have the common intrinsic motivation to give patients the best healthcare service possible (Mooney and Ryan, 1993). Unlike early virtual business networks, HSNs do not "fail" because every node is only committed to its own success.

Major features of an HSN are: 1) common goal of all network stakeholders is to increase the network's HSQ, 2) mostly long-term cooperation especially for patients suffering from chronic conditions, 3) value creation is achieved collaboratively, 4) members of the network do not explicitly enter the HSN because they are passively linked through the necessary information flow, and 5) low degree of contracting, hence high importance of trust, between network participants. Healthcare services are highly specialized and healthcare service providers individually provide only a small part to overall patient value, i.e. patient health quality. Even though the common goal is to increase the network's HSQ, it is unlikely that the stakeholders will tolerate decreasing business value to achieve this goal. Thus, sometimes it is only beneficial for the patient if all the stakeholders work together and there is not necessarily an intrinsic motivation to cooperate. Therefore, when improving coordination, the incentives proposed to the stakeholders have to be very well established.

2.2.4 Disease-specific Healthcare Service Networks

Since patients' require disease-specific services, the required coordination also needs to be disease specific. Thus, healthcare service networks are focused on one disease. In this work, a stroke-specific HSN is chosen because stroke is an archetype of a chronic disease that generally involves many inpatient and outpatient services by different providers (Barzel et al., 2008). It is the third leading cause of death for people older than 60 in western countries (MacKay and Greenlund, 2004; World Health Organization, 2012). In Germany, for example, there are more than 250.000 newly diagnosed stroke patients every year (Statistisches Bundesamt, 2010). Of these newly diagnosed stroke patients, 38% die in the first 12 months. Furthermore, it is the leading cause of adult disability, which results in necessary constant care for a large portion of stroke survivors leaving the major burden on ambulatory care (Lindig et al., 2010). In Germany, more than 60% of the survivors are long-term disabled (Ward et al., 2005; Pohl and Mehrholz, 2008). Of these 60%, 43% need constant care in their home environment and 15% need institutional care. Average societal costs for a stroke patient in Germany are 18,517 € in the first year and rise to 43,129 € for

lifelong treatment (Kolominsky-Rabas et al., 2006). Annual costs related to stroke incidents in 2008 were 8.1 Billion Euros (Lindig et al., 2010) and prospected accumulated annual costs for 2025 are estimated to be 108 Billion Euros (Kolominsky-Rabas et al., 2006). Hence, improving HSQ along the complete patient care pathway of patients suffering from a stroke has high potential to save lives and increase health quality of a large number of people as well as decreasing societal healthcare costs due to better service utilization (less misuse) and better patient rehabilitation (earlier return to work).

A large part of these costs are produced by rehabilitation and post-acute care. Moreover, 25% of newly diagnosed strokes are re-occurrences, which might have been prevented by better post-acute stroke information management (Kjellström et al., 2007). Numerous studies have also proven that an adequate post-acute stroke management decreases avoidable deuteropathies, occupational disabilities, and the negative impact on patients' quality of life (Davoody et al., 2012; Cameron et al., 2008; Wissel et al., 2011). An integrated post-acute stroke management has therefore been proposed by many stroke patient organizations to guarantee an adequate and comprehensive post-acute care (e.g. the German Stroke Foundation or the German Society of Neurology). However, this post-acute stroke management, which would effectively coordinate interdependencies between involved stakeholders is difficult to achieve. The described HSN characteristics pose several organizational and technology-related problems. Information technology has potential to decrease these difficulties and researchers agree that its integration positively affects procedures, work practices and treatment outcomes in healthcare networks, thus contemporary post-acute stroke management's efficiency and effectiveness (Mäenpää et al., 2009; Fichman et al., 2011; Newell et al., 2013). Furthermore, as Schwamm et al. (2005) suggest, such an HSN needs to be customized for a local region to be effective.

Since it is an archetype of a chronic disease, advances in post-acute stroke management prospectively have a significant impact on improving comprehensive chronic care management while decreasing societal healthcare costs (Barzel et al., 2008; Heuschmann et al., 2010). Particularly, cardiovascular diseases as one of the major reasons for death in western countries have a large share of the societal healthcare costs (World Health Organization, 2005). Albeit recently declining death rates related to cardiovascular diseases, the burden remains high because of long-term treatments (Lloyd-Jones et al., 2010). Achieved results in stroke care can easily be transferred to other diseases that are less complex, e.g. diabetes. When considering a disease-specific HSN, general HSQ as defined in Section 2.1.2 needs to be adapted. Thus, the general HSQ metrics need to be instantiated for a disease-specific context.

2.2.5 Conclusion

In this section, inter-organizational healthcare networks have been introduced. General health network definitions and concepts of business networks and service networks have been discussed. It became evident that there is no commonly accepted health network definition, and that business network approaches do not capture the desired patient-centered, service-oriented approach along the complete patient care pathway. Since stakeholders in healthcare often compete in insulated parts of the patient care pathway, existing concepts do not describe the effects along the complete patient care pathway adequately. The involved stakeholders rather form a service network because all provide services along the patient care pathway that contribute to patient health quality. However, current concepts of service network necessarily include ICT to connect the stakeholders and facilitate information flow between them (Basole and Rouse, 2008; Razo-Zapata et al., 2012).

Therefore, the concept of HSN has been introduced and delineated to similar concepts like (smart) business networks or service networks. Unlike the current perception of service networks, the entities of the network, i.e. stakeholders such as general practitioners or ambulatory services, are not necessarily connected via the internet. Providing this concept contributes to Research Question 1, which deals with operationalizing HSQ in networks of independent healthcare stakeholders along the patient care pathway, i.e. HSNs. In such an HSN stakeholders are connected via the respective information flow. As in most networks, the information exchange is the key to coordinated processes (Heck and Vervest, 2007; de Vries and Huijsman, 2011). Coordination is an essential mechanism to effectively regulate interdependencies of different organizations, and according to Mintzberg (1979) it can be achieved by hierarchies, mutual adjustment (e.g. informal horizontal coordination) or standardization. A healthcare service network is commonly a reciprocal network, in which mutual adjustment is a valuable option for coordination (Thrasher et al., 2010). After describing inter-organizational healthcare networks, coordination – particularly in such networks – is investigated in the next section.

2.3 Related Work

Since inter-organizational coordination has been investigated exhaustively by scholars and practitioners, this section provides an overview of the related work in different fields of research such as organizational theory, economics, information systems, and healthcare. Everybody has an intuitive sense of what the word "coordination" means. For example, when looking into an operation room during surgery we see a smoothly functioning procedure with well coordinated actions of a group of peo-

ple. Often, however, good coordination is almost invisible, and we notice coordination most clearly when it is lacking. For example, when physicians prescribe a set of medications whose interdependencies result in adverse events, when during an emergency patients are rushed to the wrong hospital, or simply when the same treatment is performed twice by different physicians. For many purposes, the intuitive meaning is sufficient. However, when looking at coordination in detail, a more precise definition is needed. Malone and Crowston (1994) have accumulated several definitions of coordination from various fields. The diversity of these definitions, more precisely the different perspectives based on the research field such as computer science, economics, and organization theory illustrates the difficulty of defining coordination. Since this work takes an interdisciplinary approach, Malone and Crowston's definition is adopted.

Definition 2.9 [COORDINATION]. *Inter- and intra-organizational coordination is managing dependencies between activities (Malone and Crowston, 1994).*

Coming from an organizational point of view, inter-organizational dependencies can be governed by a variety of coordination mechanisms: discrete market transactions and hierarchical arrangements being extremes on a continuum (Goodwin et al., 2004; Powell, 1990). Coordination is an essential mechanism to effectively and efficiently regulate interdependencies of different organizations regarding individual activities and also groups of activities. When activities, responsibilities, and control structures are synchronized, overlapping efforts are avoided and resources are used more beneficial. In organizational theory, coordination is regarded as multi-faceted characteristic of a network setting rather than inquiring the theoretical optimum possible through different coordination mechanisms. Here, the three coordinating mechanisms for intra-organizational coordination postulated by Mintzberg (1979) can be adopted to describe inter-organizational coordination:

1. "**Standardization**" consists of predefined and codified tasks regarding input/output, process and worker skills. Input/Output standardization is the dominant strategy in production settings. Due to the comparability of input and output units, the network's stakeholders impose a rigid standard resulting in coordination. Process standardization is usually achieved in industrial systems where work contents like technological standards or quality certified procedures are readily available. Standardization of worker skills dominates networks in which the basic objective is exchange of specific capabilities. Each member brings to the network skills which are complementary to other members' skills and are acknowledged to be useful in achieving a common goal.

2. "**Direct supervision**" involves clear hierarchies in the network. Here a central supervisor synchronizes all other stakeholders in a network and is asserted authoritative power to guide choices of other independent organizations.
3. "**Mutual adjustment**" works through informal communication and information processes. It can be adopted in any network setting because it does not have any prerequisites.

All three coordination mechanisms rely on information flow between organizations. If there are no means to communicate standardization, authoritative instructions, or informal communication, inter-organizational coordination is not possible at all. Heck and Vervest (2007) have even concluded that simply an optimal information flow, i.e. the right information at the right time, is the key to coordinated processes in business networks. In various theories, however, obviously incommensurable definitions of inter-organizational coordination are presented. Therefore, in the following subsections, these specific theories are presented in more detail and an analysis is made of how information and the information flow are elaborated. Both research areas provide a large body of literature by itself. Therefore, the following subsections only investigate literature that discusses inter-organizational approaches and incorporates the service perspective. First, the economic perspective is discussed: Transaction cost economics, property rights, agency theory, and mechanism design. Second, theoretical information systems (IS) perspective with the more applied coordination theories in the field of information management (IM) are analyzed. Conclusively, the last subsection summarizes the state-of-the-art and introduces the underlying research model of the work hand.

2.3.1 Inter-organizational Coordination from an Economic Perspective

In economics, coordination is often studied with a special focus on how incentives and information flows affect the allocation of resources among stakeholders such as organizations or agents (Malone and Crowston, 1994). According to neoclassical economic analysis, an organization is a monolithic economic actor in a market with numerous simplifying characteristics, e.g. standardized, homogeneous products, the participants act rationally and everybody has perfect information (Hart, 1995). However, the mathematically elegant neoclassical economic analysis holds a number of seditious assumptions and closed-world market characteristics. Particularly the prerequisite of perfect information is hardly fulfilled in real markets. Hence, the so-called neo-institutional economists pursue a more realistic economic analysis, in which benefits and costs of information (and uncertainty) are taken into

account. Major streams of this economic organization studies are 1) agency theory, 2) transaction cost theory, 3) property rights theory, and 4) mechanism design.

Agency theory

Agency theory studies the role of information and information asymmetry in economic relations in two directions: The principal agent theory and the positive theory of agency (Jensen and Meckling, 1976). The former is a more analytical, normative approach in which emphasis is put on study of reward structures. The latter is a less mathematical, but more empirical approach in which the focus is put on governance instead of reward structures. In both approaches, divergence of interest between stakeholders is expressed in terms of costs. Agency theory in general focuses on situations where information sharing and trustworthy behavior are not in interests of all stakeholders involved. It investigates the reduction of global welfare by the stakeholders' behavior optimizing their own utility according to their interests. Agency theory was originally framed in conflicting interests of owners and managers acting on behalf of the owners, but it can also be applied to inter-organizational settings with one stakeholder acting on behalf of the other. However, much of the theoretical expressiveness of agency theory is diminished when one organization does not strictly operate on behalf of another. Particularly in healthcare, this is not necessarily the case for all relationships in healthcare. For example, healthcare service providers do not only act on behalf of the patient because patients often do not pay for the service⁵. Furthermore, agency theory focuses on relationships between two distinct stakeholders and does not consider triangular relationships between three or more organizations (Eisenhardt, 1989a).

Transaction cost theory

Transaction cost theory studies costs of exchange relations between separate organizations and within organizations. Transaction cost economics focuses on the application of various governance mechanisms in and between organizations, e.g. analyzing conditions under which hierarchy is a better way of coordination than a market. Like agency theory, it assumes bounded rationality acknowledging uncertainty and information asymmetries, which results in transaction costs. Unlike agency theory, it does not aim at minimizing the general welfare loss but rather the governance costs. However, transaction cost theory assumes that hierarchies reduce opportunism without specifying how (Hart, 1995).

Property rights theory

Property rights theory analyzes various kinds of user rights pertaining to scarce goods between actors in various institutional arrangements. Theory of property rights resembles reasoning of transaction cost approach but addresses its weakness of having no convincing explanation of how introducing authority mitigates oppor-

⁵Refer to Section 2.1 for further details on healthcare services.

tunism. The emphasis, however, is more on a contracting perspective. It focuses on the design of service level agreements between different organizations offering different services and products. Property rights theory also analyzes if it is reasonable to simply incorporate different organizations into one organization instead of negotiating these service level agreements.

Mechanism design theory

Mechanism design theory analyzes how to provide incentives for actors to reveal information they possess, even if they have conflicting interests. This is especially useful for designing and analyzing various forms of markets. Mechanism design is a theoretical and analytical approach by which a set of rules is identified to coordinate stakeholders. It implies that rules a network abides by can be enforced by a central entity, such as government agencies. It therefore represents an approach that looks for an optimal coordination.

From an economic perspective, the level of coordination has to be taken into account, i.e. macro, meso and micro level. The macro level deals with structure and behavior of an economy as a whole. It analyzes determinants of long-term economic factors and influence of policy makers. In contrast, the micro level considers individual behavior of organizations in allocating resources. The meso level describes the study of economic arrangements which are neither micro nor macro.

When looking at patient-centered healthcare, inter-organizational coordination on a meso level is of interest. Most of the health economic literature focuses on either macro level, e.g. optimal distribution of physicians in a certain area, or micro level, e.g. process optimization in a hospital (Meijboom et al., 2004). Moreover, the work at hand investigates characteristics of an inter-organizational coordination service that improves information flow between independent healthcare stakeholders and evaluates the service's impact in a real-world scenario. Therefore, prevailing economic theories can not be applied for the research questions motivated in 1. Nevertheless, concepts from economic theory can be exploited for service development – particularly during the incentive design.

2.3.2 Inter-organizational Coordination from an Information Systems Perspective

Inter-organizational coordination from an IS perspective is strongly tied to information management and ICT usage. Information management has a long history ranging back to the beginning of information systems. It rather encompasses managerial actions towards ICT and the information flow between different stakeholders. It deals with collecting information from various sources to reduce costs, support quality management, increase productivity of employees, or serve as a competitive

advantage. There are different variations of precise information management definitions (Krcmar, 2009; Haux, 2006), but all of them deal with intra-organizational management. They assume hierarchical power that allows to push through structural changes, i.e. introducing new ICT-structures and process changes, which are necessary for the developed strategy. According to Krcmar (2009), information management can be functionally defined as follows.

Definition 2.10 [INFORMATION MANAGEMENT]. *Information management denotes the complete administrative, governance and monitoring functions regarding the information systems in one organization with the goal of maximizing ICT's benefit for achieving the organization's goals.*

Originally, information management dealt with solutions to problems of data duplication and inconsistency by eliminating the local control over information systems. The classical approach towards information management was conceived for an entire organization or a network of organizations. Therefore, the inter-organizational definition of information management can easily be extended.

Definition 2.11 [INTER-ORGANIZATIONAL INFORMATION MANAGEMENT]. *Inter-organizational information management denotes the complete administrative, governance and monitoring functions regarding the information systems in several organization with the goal of maximizing the ICT's benefit for achieving the organizations' goals.*

Information management builds on managerial power to propose, develop and enforce ICT implementation for an entire network of organizations. It affects the common conceptual scheme of data structures and definitions across collections of data sources. When looking at the broad definition of network (see Definition 2.5) and subsequently given definitions of healthcare network that have been accumulated in Table 2.1, it becomes clear that it is difficult to apply information management tools like ARIS (Scheer and Nüttgens, 2000) in the healthcare domain. It is not necessarily the case in all networks that there is a central authority that can exert the managerial power necessary (Hill and Powell, 2009; Newell et al., 2013). Inter-organizational information management in healthcare requires independent organizations to cooperate, which makes it difficult to develop a common strategy from which business processes and necessary ICT can be deducted (Winter, 2009). One of the main applications of information management in healthcare are electronic health records (EHR) that serve as information sink for patient data. All the patient data is supposed to be available in one record to reduce costs, improve information flow between stakeholders, and increase quality as well as productivity of healthcare services by eliminating multiple data sets. However, in practice adoption is often dif-

ficult (Fichman et al., 2011). For example, many primary care offices are very small, making costs of adopting prohibitively high (Hill and Powell, 2009; Meijboom et al., 2010). In contrast, introducing an EHR across a large national healthcare system is also problematic because of diverse needs and interests that must be accommodated (Blechmann et al., 2012; Newell et al., 2013). Since information management is already complex in single organizations, applying the common three layer information paradigm (strategy, process, and system view) in a networked healthcare setting is challenging (Gusew et al., 2012; Mäenpää et al., 2009; Winter, 2009).

There are numerous examples of national health information systems that have not achieved anticipated results. One prominent example is the NHS National Program for IT (NPfIT) in the UK. It has been fraught with difficulties and finally being deemed "unworkable" in August 2011 after 2.7 billion pounds had been spent⁶. Similar consequences might happen in Germany where the eHealth Card has been under development for more than ten years, yet, there are but pilot regions that utilize it⁷.

In contrast to large-scale approaches, there are several rather local initiatives that are in operation. This is in line with the findings of Schwamm et al. (2005), which conclude that local coordination initiatives in healthcare can be effective. A local healthcare integration network (LHIN) in Ontario Canada (Bhandari and Snowdon, 2011), and a Dutch version called "virtual integration of healthcare" is in practice. A Finnish electronic patient record solution has been designed and its implementation approved, however, its usability has not been described (Saranummi et al., 2007). The Rhône-Alpes Health platform is in a similar state (Durand et al., 2007). In Germany, there are also several smaller sized networks. For example, e.Health Braunschweig, which is a network consisting of a large hospital and several outpatient providers in the region of Braunschweig (Gusew et al., 2012).

Mäenpää et al. (2009) have performed a systematic literature review of successful and sustainable inter-organizational health information systems. They have classified regional health information systems in four categories. Even though they presented several health information systems that are still in practice, they have not identified any striking characteristic what makes them successful – apart from being regional. Also other authors have not been able to identify key success factors during the implementation of local healthcare integration networks (Bhandari and Snowdon, 2011; Saranummi et al., 2007; Durand et al., 2007).

Summarizing, inter-organizational information management and ICT usage are mainly viewed as means to provide an information sink for medical data that all

⁶Report of the National Audit Office <http://www.nao.org.uk/> (last accessed December 2013)

⁷Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH: <http://www.gematik.de/> (last accessed December 2013)

involved stakeholders can easily access (Winter, 2009). Particularly on a national level, using health information technology for information management has a large potential to improve healthcare. However, there are few national initiatives providing an operational solution that at least partially realizes the desired functions. This is mostly rooted in the strong fragmentation of the healthcare domain. As opposed to large inter-organizational ICT-structures, there are several successful regional approaches. Since ICT plays a vital role in improving information flow between different organizations, improving coordination based on regionally implemented ICT seems promising.

2.3.3 Coordination in Healthcare Service Networks

Missing coordination along the complete patient care pathway leads to overuse, misuse, or underuse of healthcare services (Johnston, 2004; Bodenheimer, 2008; Ovretveit, 2011). The latter is more common as it is difficult for patients to locate the right service at the right time (Bhandari and Snowdon, 2011). Either way, suboptimal service usage creates problems for all the stakeholders in a healthcare service network. Healthcare service providers might perform healthcare services with less quality or not all. For patients as healthcare service consumers – apart from inducing a suboptimal convalescence – this may lead to decreased motivation and subsequent lower treatment adherence or worse secondary prevention in the post-acute phase. Even service payers that are not explicitly part of the HSN are affected by missing coordination along the patient care pathway. It induces inadequate healthcare service utilization which in turn leads to unreliable prediction of supply and demand.

In the previous subsections, inter-organizational coordination was presented from an economic and from an IS perspective. The state-of-the-art literature lacks a long-term perspective on inter-organizational coordination on a meso level. Particularly, a long-term perspective on improving coordination along the complete patient care pathway. This is essential for patients suffering from chronic diseases because they require long-time attention of multiple healthcare service providers. Coordination in inter-organizational healthcare settings is difficult when compared to other domains because of two unique factors. First, complexity and heterogeneity of the provided services require participation of a number of very different professionals in terms of knowledge and expertise as well as different cultures and values. Increase in disease treatment variety in combination with technological innovations triggers functional specialization. Because of this proliferation of clinical specialization, standardization of input/output, processes or worker skills is hard to achieve. Second, fragmentation paired with traditional values of healthcare service providers

makes establishing inter-organizational hierarchies difficult. For example, physicians commonly have strong ties with culture standards and ethical values of their profession. This contradicts being a network member that has to oblige rules and objectives that are contrasting their own interest or values.

There are few publications about inter-organizational information management that consider the complete patient care pathway on different levels (Winter, 2009). Most either focus on technical issues, process optimization, or health policy strategies. In Figure 2.2 an overview of the relevant state-of-the-art literature that takes more than one aspect into account is presented. To improve the information flow along the complete patient care pathway and, hence, coordination in a healthcare service network, organizational aspects such as incentives and processes as well as technological aspects have to be taken into account. Furthermore, as argued before, a patient-oriented perspective on coordination is needed to sustainably improve the HSQ in an HSN (Berwick, 2009; Kaplan and Porter, 2011).

Literature	Incentives-Strategy	Processes	Infrastructure	Coordination
(Schicker et al., 2008)	●	◐	◐	○
(Newell et al., 2013)	◐	○	◐	◐
(Ovretveit, 2011)	●	○	○	●
(Bodenheimer, 2008)	●	○	○	●
(Meijboom et al., 2004, 2010)	●	●	◐	○
(Gusew et al., 2012)	◐	◐	●	○
(Hellrung et al., 2008)	○	●	●	○
(Blechmann et al., 2012)	○	●	◐	◐
(Pirnejad et al., 2008)	○	◐	●	○

Table 2.2: Compilation of the related work in the field of inter-organizational coordination in healthcare.

The related work that considers all three aspects: Strategic viewpoints, process alterations, and infrastructure requirements, such as (Gusew et al., 2012), (Schicker et al., 2008), or (Meijboom et al., 2010), do not take a patient-oriented view and, therefore do not improve coordination along the complete patient care pathway. Here the e.Health initiative Braunschweig, Germany described by Gusew et al. (2012) serves as a good example. It analyzes a regional network of healthcare service providers, and considers strategic incentives, process alterations, and changes in ICT to improve transition from hospital to post-acute treatment. The perspective is that of the largest hospital in that network, which provides patient data access to outpatient facilities like general practitioners. Albeit the difficulty and practical significance of this endeavor, coordination is not improved along the com-

plete patient care pathway. Other publications aim at improving coordination in an HSN but fail to consider technological aspects. For example Bodenheimer (2008) or Ovretveit (2011) take a macro perspective. On a technical level, there are promising approaches to coordination that neglect the strategical perspective. For example, Pirnejad et al. (2008) and Blechmann et al. (2012) take a promising approach to coordination by implementing a flexible ICT for inter-organizational coordination. Newell et al. (2013) try to implement a single point of contact (SPOC) for children with complex medical needs in a patient-oriented manner. However, they merely update an existing ICT-structure and completely disregard the processes.

As shown in Table 2.2, none of the state-of-the-art approaches takes a patient-centered coordination approach that considers strategy, processes, and the underlying ICT. When taking a patient-centered approach to coordination, information flow is required to be translated rather than simply transferred between the stakeholders. It is not a simple "end-to-end" communication because, for example, patients do not necessarily "understand" what the doctors say. Therefore, simply applying information management in the sense of supplying access to information is not expedient – let alone the challenges of applying the common three layer information paradigm (strategy, process, and system view) in a networked healthcare (Mäenpää et al., 2009; Winter, 2009).

2.4 Conclusion

In this chapter the fundamentals of healthcare services, inter-organizational healthcare networks, and the related work with respect to inter-organizational coordination has been presented. In doing so, Research Question 1 has been investigated. This chapter deals with the operationalization of coordination in a network of independent healthcare stakeholders. In Section 2.1, differences between healthcare services and the "general" service conception were delineated, and HSQ was defined. The HSQ definition is based on the healthcare quality concept of Donabedian (1988) that takes structure, processes and outcome into account. In Section 2.2, the fundamentals regarding healthcare networks were presented. This section illustrated the ambiguous healthcare network definitions and discussed the concepts of (smart) business networks and service networks. Furthermore, in this section the concept of an HSN was introduced, which describes a network of independent stakeholders in a healthcare network along the complete patient care pathway. Based on the two sections, related work in inter-organizational coordination was assessed in Section 2.3. This section argued that there is no approach that tries to improve coordination in an HSN, i.e. along the complete patient care pathway, by altering the existing ICT-

structure and processes while also considering a strategic perspective – providing incentives for the involved stakeholders.

When investigating information management in an HSN, apart from the employed ICT and process design, incentives and cultural values of the involved healthcare stakeholders have to be considered, too. In such networked settings, information flow between involved stakeholders has a strong influence on the HSQ. Thus, if coordination of information and healthcare services was improved, HSQ would also be improved. As depicted in Figure 2.4, the information flow between HSN stakeholders – among other factors – strongly influences HSQ (Bodenheimer, 2008). In turn, the information flow depends on the coordination and other external factors, such as laws or social ties. When neglecting external factors that only policy makers can influence, a model to operationalize HSQ in a network of independent healthcare stakeholders, i.e. an HSN, is introduced. Building on extending existing theory, this work contributes to an operationalization of HSQ as intended by Research Question 1.

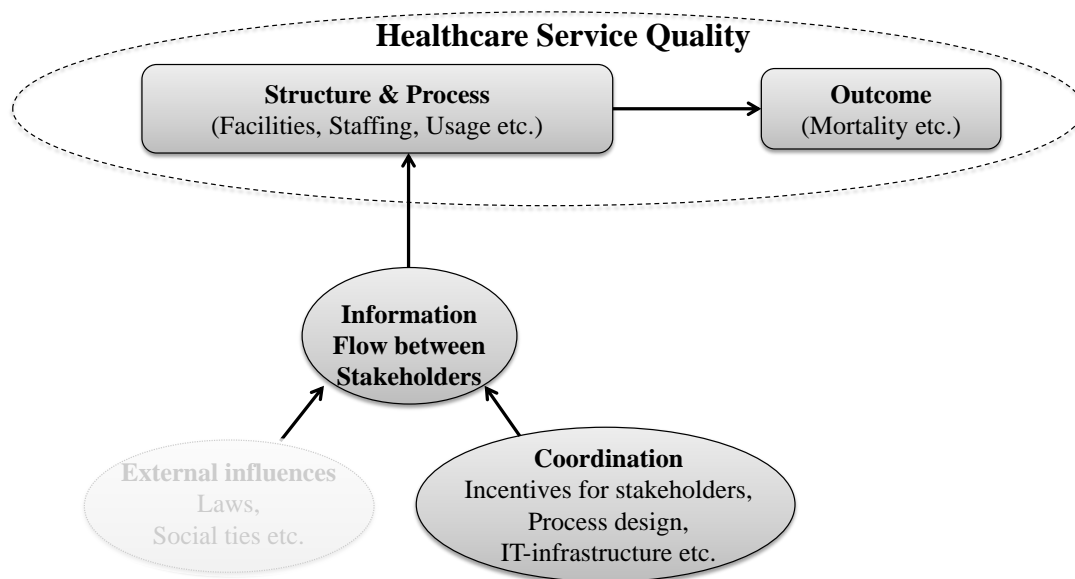


Figure 2.4: Research model of this thesis.

Providing a coordination service in order to improve information flow and, thus, HSQ in an HSN, has been undermined in this section. Since such a service requires alterations on structure and on process level, existing medical pathways and workflows need to be altered comprehensively. Furthermore, it has been shown that financial incentives alone cannot align individuals' preferences and guarantee coordinated behavior regardless of organizational structure and economic circumstances (Page, 2003). Thus, instead of short-term economic motivation, incentives for the involved stakeholders to utilize the coordination service need to be carefully inves-

tigated. Otherwise, the intended effects of the service will either not be materialized at all or they will not last for a longer period of time. Consequently, the work at hand investigates development, validation, and evaluation of a coordination service that improves HSQ in an HSN.

Part II

Developing the Coordination Service Concept

Chapter 3

Service Development Fundamentals

In the previous part, healthcare service fundamentals are presented and the concept of patient-centered coordination is introduced. In doing so, the previous chapter motivates that a central service can effectively decrease the existing information deficits in an HSN. Such a service is a feasible option to ameliorate coordination in an HSN by improving the information flow between stakeholders. This and the following chapter deal with the development of a central coordination service that is capable of providing such a solution. In particular, this chapter gives an understanding of fundamentals that are necessary for developing and validating the service. First, various service engineering approaches are presented in Section 3.1, which are state-of-the-art methods for developing services in a structured manner. They are discussed regarding their suitability for the specific healthcare context. Second, Section 3.2 deals with service development. This section provides the methodology necessary for studying Research Question 2, which investigates the characteristics of an effective coordination service that improves HSQ in an HSN. Third, similar, more practical service concepts for coordination in HSNs are presented in Section 3.3. In this section, existing concepts of post-acute support are assessed, in order to provide the basis of related work that has been drawn upon during the service development. Since stroke is an exemplary chronic disease that involves many healthcare service providers (Barzel et al., 2008), concepts of post-acute stroke are investigated in particular. Furthermore, stroke-specific characteristics of the patient care pathway are described. In the last section of this chapter, a summary is drawn about the devised service engineering methodology.

3.1 Service Engineering

Most services have characteristics, which generally distinguish them from products (Hill, 1977; Lovelock, 1983; Vargo and Lusch, 2004; Spohrer et al., 2007). For

example, customers' or – adapted to the healthcare setting – consumers' value co-production has to be taken into account. Thus, the methods to support the intuitive service development differ from common product development (Bullinger and Schreiner, 2003). Looking systematically at product development from a practical and theoretical perspective has been done since the early 20th century. Yet, the theoretical perspective on designing services emerged only in the 1980s (Shostack, 1982). By the 1990s, the research discipline service engineering had been established. There are two major trends: The design-oriented approaches that initially investigated the adoption of engineering concepts from software development (Bullinger and Scheer, 2006); and the research field service science, management and engineering (SSME) in which more fundamental service research questions such as the impact of the general service-dominant-logic are investigated (Maglio et al., 2006). The work at hand recognizes service engineering as a means to systematically develop an abstract coordination service to improve coordination in a healthcare service network. Thus, engineering concepts are investigated more closely and the SSME literature is neglected. Based on Bullinger and Schreiner (2003) service engineering is defined as follows.

Definition 3.1 [SERVICE ENGINEERING]. *Service Engineering is the systematic development of innovative services using distinct process models, methods and tools. Service Engineering involves all activities along the service life cycle: Conception, development, implementation, and validation by customer use. It takes strategic and organizational design factors into account (Bullinger and Schreiner, 2003).*

In the following subsections, the most prominent design-oriented approaches are presented and discussed

3.1.1 Service Engineering Perspectives

When looking at service engineering approaches, the perspective regarding the service's goal is important (Leimeister, 2012). Based on the constructs that define service quality (Bullinger and Scheer, 2006), service engineering has three major perspectives (1) *potential*, (2) *process*, and (3) *outcome*. Subsection 2.1.2 provided an exact definition of service quality, particularly healthcare service quality, and an illustration of its components in Figure 2.2. The first perspective, the service potential perspective, investigates structural features of the service that serve as "input" during service creation such as information and communication technology, human resources, or available information. These structural features are provided by both, service provider and service consumer. The service process perspective looks at the actual service provisioning and simultaneous service consumption. Integrating the

customer in the process poses several challenges because the customer needs to have physical, intellectual, and emotional capabilities to participate in the co-creation of the service (Bullinger and Scheer, 2006). Here, existing information asymmetries are reinforced because providers do not know how much consumers want to participate and consumers cannot easily judge service providers' qualification as well as their service quality. The service outcome perspective has two parts: The *procedural outcome* and the *impact* of the service. The former includes short-term results, such as performing the service as intended. The latter includes rather long-term results of the performed service. In healthcare, for example, procedural outcome is a successful operation or adhering to medical procedures, whereas impact is signified by a more holistic, long-term measure. For example, one long-term outcome measure is patient health not immediately after the service consumption, i.e. long-term effects of a surgery.

In addition to the three mentioned service perspectives, the market perspective also needs to be taken into account for service engineering (Leimeister, 2012). It focuses on the potential customers' perspective and their valuation of the service. If the market perspective is neglected, it might be the case that the designed service does not match the market's need. Even if the three major perspectives, i.e. potential, process, and outcome, have been considered, the service might not be successful because the potential customers do not appreciate the service's benefits. Participatory approaches, such as prototyping, encounter the pitfall of "designing the service past the customer," which is pointed out by Tien and Goldschmidt-Clermont (2009). However, this assumes that the customer is always the consumer of the service. As described in Section 2.1 this is not necessarily the case because the consumer of a healthcare service might be the patient whereas the customer, i.e. the person that pays for the service, might be some other healthcare stakeholder such as a health insurance. Therefore, whether the market perspective is taken into account has to be decided depending on the individual application.

3.1.2 Service Engineering Approaches

Since this work aims at improving HSQ which comprises structure, process, and outcome (see Section 2.1.2), only service engineering approaches that take all three perspectives into account are considered in the following. The existing approaches are often divided by their underlying model: Linear models in which there are distinct process steps that are executed one after another; iterative or spiral models that allow repeating certain processes steps until possible errors are eliminated; or prototyping models that aim at creating a prototype as early as possible to refine the service in practice (Bullinger and Schreiner, 2003). Linear models are used most

	Shostack (Shostack, 1982)	Scheuing and Johnson (Scheuing and Johnson, 1989)	Edvardsson and Olson (Edvardsson and Olsson, 1996)	Ramaswamy (Ramaswamy, 1996)
systematization	●	●	○	●
configurability	●	○	●	○
level of detail	●	●	○	●
customer integration	○	●	●	●
usage in practice	●	○	○	●

Table 3.1: Comparison of major service engineering approaches regarding their characteristics rating ○= low, ●= medium, and ●= high (cp. (Fährnich and Meiren, 2007)).

often because of their process-orientation and ease of use. However, these benefits come at the expense of low flexibility due to the missing possibility to incorporate feedback from later process steps. In Table 3.1, the most prominent service engineering approaches are illustrated and compared regarding different characteristics. According to Fährnich and Meiren (2007), systematization, configurability, possible level of detail during development, customer integration, and previous usage in practice are striking characteristics of service engineering approaches.

One of the first models supporting service engineering was conceived by Shostack in 1982 (Shostack, 1982). It includes several concepts supporting systematization and configuration while providing a medium level of detail. Even though it has been used in practice – in contrast to many other service engineering approaches – it does not include customer integration. This has been addressed by Scheuing and Johnson in 1989 (Scheuing and Johnson, 1989) as well as Edvardsson and Olson in 1996 (Edvardsson and Olsson, 1996). Both papers describe two different service engineering approaches that explicitly demand future customer input during the development phase (Scheuing and Johnson, 1989; Edvardsson and Olsson, 1996). However, neither of these approaches have been used in practice.

In contrast, the service engineering approach of Ramaswamy from 1996 (Ramaswamy, 1996) provides a high level of systematization, detail, and customer integration, and it has been applied in practice multiple times. It is therefore superior when customer involvement is essential (Fährnich and Meiren, 2007). Its major drawback is the lack of configurability, which means that creating different versions of one service is not supported by the model. This drawback is made up by its cyclic methodology that is divided into two phases, one for service design and one for service management. It facilitates continuous improvement of the engineered service.

In the service design phase, customer needs are analyzed, service attributes are defined accordingly, and service concepts are developed and validated. In the service management phase, the service is implemented, its performance is measured, customers' satisfaction is assessed, and possible improvements are postulated.

In past years, several other approaches have been proposed that either focus on single aspects or describe a more general, holistic model. For example, (Menschner and Leimeister, 2012) and (Peters and Leimeister, 2013) have developed specific service engineering methods that focus on "person-oriented" services and "telemedicine" services, respectively. However, few of the recently developed service engineering approaches have been used in practice, which is a major drawback.

Choosing the right service engineering approach depends on numerous factors. For example, expected magnitude of the new service or its already known must-have characteristics influence the choice significantly. Depending on the field of application, each of the introduced design-oriented service engineering approaches has its advantages.

3.2 Methodology for the Service Development

When determining the methodology for the work at hand, one needs to recall the underlying idea: Improving coordination in healthcare service networks to improve the healthcare service quality. Chapter 2 describes how an improved information management, i.e. increased information flow between the independent stakeholders of an HSN, improves the coordination and affects the network's healthcare service quality. Following the service-oriented perspective, a coordination service that improves the information flow in the HSN is investigated. In line with the findings of (Page, 2003) which proposes that changes in healthcare networks should be made incrementally, the service development proposed in this work is done incrementally. Instead of only modeling an HSN and designing a service that has the characteristics to induce the optimal information flow, the service is developed in stages, each of which improves the HSN's current information flow incrementally. Consequently, the coordination service is updated from stage to stage during the development. Every service stage is analyzed and updated, for example by providing better ICT, to increase the improvement in information flow iteratively.

3.2.1 Service Engineering Methodology

Since this work aims at creating a coordination service that is evaluated in real-world scenarios, apart from a research methodology for evaluating the service, an

advanced engineering method is needed. In the previous section, the service engineering approaches' benefits and the disadvantages have been discussed. Ramaswamy's service engineering approach (Ramaswamy, 1996) has – compared to other approaches – excellent characteristics regarding customer integration and systematization. Furthermore, it is of cyclic nature allowing iterative updates. The approach incorporates two phases, which consist of four distinct steps each (see Figure 3.1). In the service design phase, the customer needs are analyzed, the service attributes are defined accordingly, and service concepts are developed and validated. In the service management phase, the service is implemented, its performance is measured, the customer's satisfaction is assessed, and possible improvements are postulated. Based on the evaluation results from the service management phase, another cycle of service design and management may start with improved prerequisites.

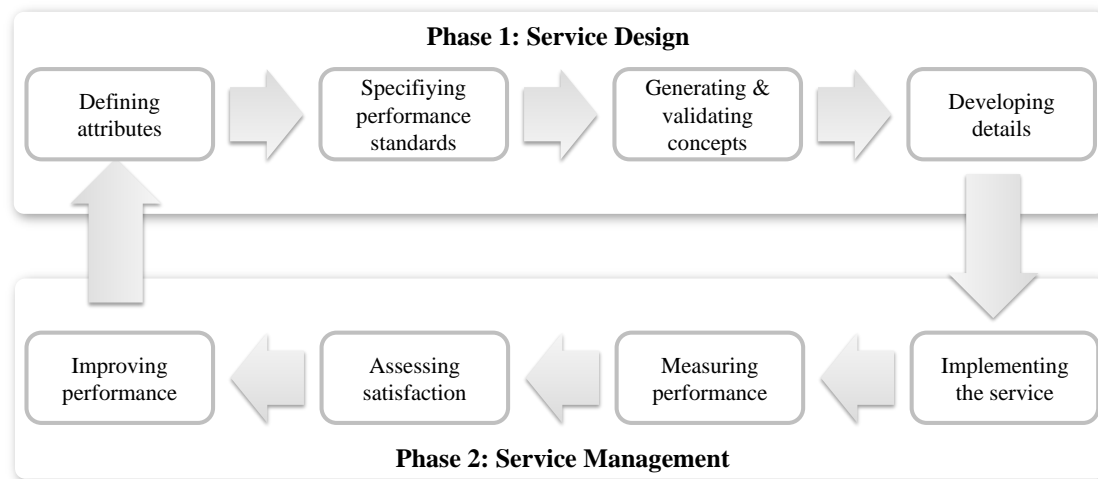


Figure 3.1: Illustration of the cyclic service engineering as proposed by Ramaswamy (1996)

In detail, service design proceeds as follows. During the first step of the design phase, key customers are identified and their needs are determined. These needs are prioritized and transformed into more quantifiable attributes. The attributes are then again investigated to determine the most important ones. The second step is a drill-down of the identified attributes: Key customers' desired performance level and competitors' current performance levels are analyzed. Consequently, performance standards are created for each of the identified design attributes that serve as input for the third step, in which possible concepts of the novel service are generated and evaluated by defining key functions and processes. In the final step of the design phase, design details of the selected service are elaborated. Here, the service concept is partitioned into process-level design components and alternatives for each component are generated and validated. Consequently, the best concept

is chosen to be implemented and evaluated in the following service management phase.

As shown in Figure 3.1, the service management phase starts with the fifth step, in which the service design is implemented using project plans, construction plans, roll-out plans, etc. Then, in the sixth and seventh step, the service's impact regarding the identified key attributes is analyzed by measuring performance and customers' satisfaction. During these steps, results are validated against those from the second step in the design phase. The performance is analyzed for each attribute individually and, if necessary, corrective actions are initiated. Based on these specific analyses, in the last step the entire service is evaluated and improvements for its performance are postulated. Furthermore, new strategic goals regarding single attribute performance or possible process-level improvement alternatives are set or selected, respectively. Particularly, the initiation of process-level improvements starts another cycle of service design and management if the evaluation of their costs-benefit-analysis yields a positive result.

3.2.2 Service Research Methodology

Apart from a sound methodology for development, implementation, and validation of the coordination service, a research methodology is necessary that facilitates a scientific evaluation of the service and its components, especially the ICT. With respect to Research Question 2, which investigates what characteristics a service needs to possess to improve the information flow in an HSN, a research methodology is needed that allows drawing general conclusions from the engineered service. In information systems research there are two prevalent perspectives on research methodology: behavioral and design-oriented (Hevner et al., 2004). Design-oriented approach as described by Hevner and Chatterjee (2010) is a "problem-solving paradigm" that has its roots in engineering. This approach addresses solving a "wicked problem," which according to Hevner and Chatterjee (2010) is characterized by unstable requirements, complex interactions, and critical dependence upon human cognitive or social abilities. However, Research Question 2 does not focus on service engineering but rather investigates interactions among people, technology, and organizations. Furthermore, subsequently investigated Research Question 3 aims at providing researchers and practitioners insights into how to improve effectiveness and efficiency of inter-organizational coordination. Thus, a research method from behavioral perspective fits the raised research questions better, for example the case study methodology.

Case study approaches focus on understanding dynamics in single settings (Ragin and Becker, 1992; Yin, 2008). It is a research strategy primarily for social sci-

ences that is nonetheless widely accepted in IS research (Lee, 1989; Eisenhardt and Graebner, 2007) and the preferred research strategy when rather exploratory research questions are answered, little control over events is possible, and real-life phenomena are studied (Yin, 2008). Particularly, the exploratory character of identifying requirements for such a coordinating service – as addressed by Research Question 2 – favors the case study approach because this evaluation method tries to illuminate why certain decisions were taken regarding their specific implementation and their results. Neither experiments nor any isolated ex-post data analysis, like surveys, can yield such a multitude of research insights as implementing and analyzing a service in a real-life environment (Klein and Myers, 1999).

Therefore, the work at hand used a case-study-based evaluation method, which has been proposed by Yin (2008), in order to provide the mentioned multitude of insights. This evaluation method was embedded in the engineering methodology that has been presented in the previous section (see for example Figure 3.1 for a detailed overview). Halinen et. al (Halinen and Tornroos, 2005) have used a case approach in the area of business networks, and note that the method always involves a trade-off between boundary settings, complexity, temporality and cross-case comparability but is appropriate for multidisciplinary work. Particularly in healthcare, cross-case comparability is difficult to achieve because of individual patient characteristics. Furthermore, providing multiple cases in healthcare does not only imply more effort but also possibly puts more patients' health at risk. Consequently, the chosen evaluation methodology took a single case approach. According to (Eisenhardt, 1989b), this approach has research potential regarding "understanding the dynamics present within single settings" (Eisenhardt, 1989b).

Figure 3.2 illustrates different data sources the case study drew upon. Since a case study is a "triangulated research strategy," these multiple data sources were used to ensure accuracy and interpretation confidence regarding qualitative data (Yin, 2008). As Yin (2008) proposes, used data sources were semi-structured interviews, workshops, surveys, shadowing, documentation, and observation. Data from all these sources were acquired during the complete process of developing and implementing the coordinating service in the field.

During the service design phase, the method of data collection places an emphasis on obtaining information about intra- and inter-organizational processes. Information was obtained by analyzing secondary literature such as documents, medical guidelines, and general post-acute management practices, administering semi-structured interviews, and performing on-site observation as well as shadowing (see Figure 3.2). Using these data sources, service requirements were assessed deductively and inductively according to Mayring (Mayring, 2010). On the one hand, "top-down" deductive logic reaches conclusions from general statements, which are

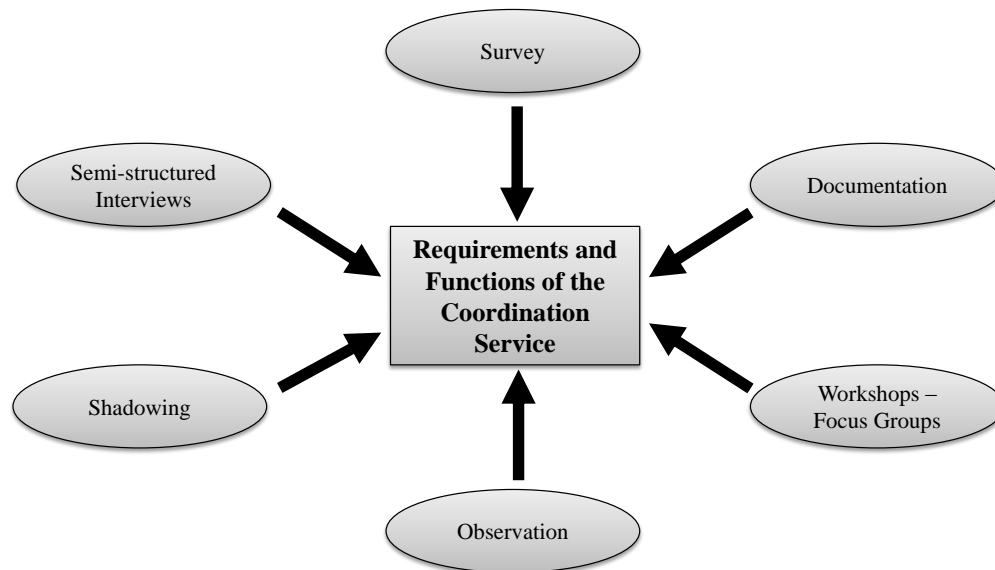


Figure 3.2: Sources that contributed to answering Research Question 2 using a case study approach (cp. (Yin, 2008))

for example postulated in the literature. On the other hand, "bottom-up" logic of inductive reasoning draws conclusions from specific examples. The former is mainly used in literature reviews, whereas the latter is used in on-site observations and shadowing. Both research strategies were applied in semi-structured interviews.

During the case study, documentation such as clinical guidelines and quality management concepts were analyzed and compared to findings in the state-of-the-art literature¹, which have largely been presented in Chapter 2. Furthermore, various stakeholders along the complete patient care pathway were interviewed in inpatient and outpatient settings, healthcare service consumers and healthcare service providers alike. Data acquisition using interviews allowed to identify issues that might have been otherwise uncaptured. An interview guideline (see Appendix A.1 and Appendix A.2) was the basis for the interviews ensuring that all previously identified topics were discussed while providing comparability across all interviews. It is more important to carefully choose interviewees that contribute the most to the research topic than to randomly pick interview partners (Mayring, 2010). Therefore, interviewees were chosen according to the theoretical sampling method (Lamnek, 1995). This means that an equal number of representatives from all involved stakeholder groups were selected for the interview. Furthermore, before interviews took place, the selected interviewees were screened to ensure that they are an appropriate sample.

¹Manual literature review included a search in large scientific databases, e.g. Ebsco Host, Google Scholar, ISI Web of Knowledge, JSTOR, PubMed, Science Direct, Scopus, and SpringerLink, with the key words stroke, apoplexy, poststroke, postacute, rehabilitation, coordinator, navigator, manager, coordinated, managed, integrated, and network. Furthermore, current German and English stroke guidelines, e.g. AHA Guidelines, DEGAM recommendations, or Stroke foundations guidelines.

These interviews were assessed using a mix of qualitative and quantitative measures as proposed by Mayring (Mayring, 2010). First, interviews were transcribed and decoded, which signifies that the information is clustered in predefined categories according to main topic. Second, decoded interviews were analyzed in a qualitative and quantitative manner. The former – a rather exploratory way – allowed to create new hypotheses from the data, which are in this case coordination service requirements. The latter – a more quantitative interview analysis – evaluated ex-ante hypotheses by assessing the interviewee's statements regarding these specific topics.

In addition to the interviews, data was obtained from shadowing, observation, and focus group discussions in workshops. These data acquisition methods are more flexible and allow capturing unexpected information that interviewees often even cannot reveal using communication. Especially focus groups provide a means to obtain information directly from individuals faster than in one-on-one interviews if the drawback of possible group dynamics is accounted for.

During the service design phase, interviews and literature were mainly used to define the service attributes and specify the performance standards. Findings of initially acquired data were compared to and refined with data obtained from shadowing, observation, and focus groups. In the course of the case study, service concepts were generated, validated, and developed in more detail before the service was implemented and assessed.

3.3 Healthcare Coordination Concepts in Practice

Since constricted information flow and missing coordination have already been recognized as one of the major causes of poor healthcare quality (Leutz, 1999; Bodenheimer, 2008), there are various concepts and projects that tackle these problems. In this section, related concepts, which are already applied in contemporary healthcare settings, are introduced and their lack of ICT usage is exposed. First, current approaches to coordination in healthcare such as *integrated care (programs)*, *disease management (programs)*, and *case management (programs)* are specified and their particular characteristics are highlighted. In doing so, concepts' different approaches are described and they are delineated to a coordination service. Then, characteristics of post-acute stroke treatment are introduced to give an understanding of the field of application.

3.3.1 Managed Care

Practitioners, particularly large health maintenance organizations, have recognized that the coordination regarding patients suffering from chronic diseases is insufficient (Bodenheimer, 2008). The problems of patient data exchange among the healthcare service providers and individualized information provision for the healthcare service consumers are acknowledged. Concepts like integrated care (programs) and disease management (programs) have been developed to reduce these problems by managing the provided care (Gröne and Garcia-Barbero, 2001; Ouwens et al., 2005).

Integrated care aims at creating new organizational arrangements and enhancing the professional cross-group collaboration between healthcare service providers to avoid healthcare service overuse, underuse, and misuse (Ouwens et al., 2005). It is also known as coordinated care or comprehensive care, and the WHO gives the following definition in its position paper in the international journal of integrated care: "Integrated care is a concept bringing together inputs, delivery, management and organization of services related to diagnosis, treatment, care, rehabilitation and health promotion. Integration is a means to improve services in relation to access, quality, user satisfaction and efficiency" (Gröne and Garcia-Barbero, 2001). In the USA, Kaiser Permanente or the Veterans Health Administration are two of the largest health maintenance organizations (HMO) and thus large integrated care delivery systems. They integrate horizontally at the same level of the value chain, for example through acquiring several rehabilitation facilities, and vertically along the value chain, for example by merging acute treatment and rehabilitation. In Germany, up to now, there are no comparable HMOs. There are horizontally integrated systems, for example large hospital associations like Asklepios Kliniken GmbH, HELIOS Kliniken GmbH, Sana Kliniken AG, or Rhön Klinikum AG. Vertical integration is health-insurance-driven and mainly realized by selective contracts. This vertical integration is based on promotion of cross-sectoral cooperation and adoption of economic responsibilities at healthcare service provider level (Derouiche et al., 2011). It fosters specialization of healthcare service providers because the increasingly complex range of healthcare services makes it nearly impossible to provide a large number of heterogeneous services efficiently. Thus, providers specialize for a competitive advantage, and consequently, quality is improved by simple experience curve effects. However, the downside is a possible decline in personal relationship between patient and physician, and patients that are only allowed a limited number of service providers depending on their health insurance. Moreover, it further increases necessary communication and coordination between different providers.

Disease management is defined as "a system of coordinated healthcare interventions and communications for populations with conditions in which patient self-care

efforts are significant."² These populations consist of people who need regular routine follow-ups – usually of various different healthcare service providers – and are at high risk of exacerbating their state of health. Disease management programs aim at supporting physicians in planning adequate care, emphasize patient empowerment as well as prevention, and provide ongoing evaluation of improved patient health. Nevertheless, a common detailed definition is missing and disease management programs are widely heterogeneous, thus, limiting their comparability. Furthermore, existing approaches focus on specific diseases, such as diabetes, heart diseases, or cancer, rather than determinants such as weight control and physical activity (Leutz, 1999). They rather concentrate on the reduction of future complications regarding a specific disease, and focus on the disease. Therefore, disease management is commonly seen more as an inherent part of integrated care concepts or even case management, which is presented in the following section.

Concepts of integrated care and disease management programs provide numerous advantages, however, their use at patient level is complex because patients need to be well informed to exploit the programs' advantages and the contractual setting demands more effort from all involved stakeholders (Ouwens et al., 2005). The perspective is not only focused on healthcare service providers, but also on improving existing processes. Therefore, when ICT is incorporated in these concepts, it is simply used to replace existing documentation instead of leveraging its potential to transform existing processes. Additionally, for these concepts to unfold their power, they have to overcome existing trenches between different service providers like general physicians, surgeons, occupational therapists, and many more to allow cooperation between fragmented fields of healthcare service planning, provisioning, monitoring, and reviewing.

3.3.2 Case Management

In contrast to integrated care and disease management programs, case management is seen as support for people with complex needs who are high-intensity users of secondary care. Usually, people suffering from one or multiple chronic diseases are mostly in need of such a support (Ouwens et al., 2005; Bodenheimer, 2008). The primary goal is to improve patients' functional, emotional, and psychosocial condition by providing individual healthcare services. For example, Crawley (1996) have shown that case management improves outcomes of stroke patients. Case management's focus is therefore more patient-centered than that of the other programs. The case manager informs patients and care-giving relatives with the right information at the right time while taking care that patients takes advantage of available

²Disease management definition by the Care Continuum Alliance (CCA): <http://www.carecontinuumalliance.org/> (last accessed December 2013)

healthcare services. Making sure that the patient uses the available healthcare services involves coordinating various healthcare service providers under predefined economic, clinical, and social constraints. In Germany, case management had not been employed until the end of the past decade, and the German Society for Care and Case Management ("Deutsche Gesellschaft für Care und Case Management - DGCC") has been founded as late as 2006³. The concept's practical integration is therefore not as advanced as in the USA (Wendt and Löcherbach, 2011).

Case management is defined as "a collaborate process of assessment, planning, facilitation, care coordination, evaluation, and advocacy for options and services to meet an individual's and family's comprehensive health needs through communication and available resources to promote quality cost-effective outcomes" by the American Case Management Association⁴. It involves one person or a group of people, usually called case manager, to take over responsibility for coordinating healthcare services of individual patients for a distinct period of time (Wendt and Löcherbach, 2011). Core competences of a case manager are communication, situation assessment, planning, networking, and evaluation. Consequently, it pursues the "local care coordination" approach to improve information sharing between different stakeholders in an HSN, which was proposed by Meijboom et al. (2010).

In theory, case management is a process divided into five different phases, in which patients' healthcare service needs are 1) assessed, 2) planned, 3) coordinated, 4) monitored, and 5) evaluated. In the assessment phase, patient data is recorded to determine if and what healthcare services the patient needs according to apparent health condition. This data ranges from information about patients' cognitive state up to their current financial situation. After assessment, the case manager decides – based on specific, clearly defined criteria – if the patient is eligible for case management. The target patient group is generally in need of cost-intensive care provided by multiple healthcare providers. This applies to patients suffering from chronic diseases, for example stroke patients. In the plan phase of case management, an individual and appropriate care plan is created. Essential elements of this phase determine objectives to be achieved by the involved stakeholders (including criteria and indicators to measure the achievement), corresponding responsibilities, necessary healthcare services, and available healthcare service providers. In the third phase, the case manager coordinates healthcare services and ensures availability of resources, personnel, and required information. Given the continuity of care objective, an important element in this process is early and efficient discharge planning. For this purpose, the case manager needs to establish and maintain a stable coop-

³further information in German is available at <http://www.dgcc.de/> (last accessed December 2013)

⁴Case management definition by the Commission for Case Manager Certification (CCMC): <http://ccmcertification.org/> (last accessed December 2013)

eration network of healthcare service providers. Apart from planning and coordinating healthcare services along the patient care pathway, the case manager also monitors and evaluates the services' implementation. In the monitoring phase, the case manager monitors the planned implementation. Occurring deviations of the plan caused by the involved stakeholders – either the patient or individual healthcare service providers – are addressed by the case manager. In the evaluation phase, results are analyzed for healthcare quality assurance and future improvement. In addition, the evaluation offers insights into resource management and market positioning of involved healthcare stakeholders (Wendt and Löcherbach, 2011).

3.3.3 Concept Assessment & Implications

Even though the three introduced care coordination concepts are often seen as different healthcare networks, they are similar in terms of inter-organizational coordination. In general, they are more on the right side of the healthcare network continuum described by Goodwin et al. (2004) (see Figure 2.3 in Section 2.2). In practice, all three concepts are mostly applied as *procurement networks* or *managed networks* because the independent stakeholders have contracts to allow coordination and enforce commitment. Thus, the inter-organizational coordination is mostly regulated by contracts and few are *informational networks* or *coordinated networks* that would leave the stakeholders independent regarding financial and medical responsibilities. Additionally, none of the introduced concepts distinctively leverages ICT to transform existing processes along the complete patient care pathway. Both approaches, management care and case management, merely use ICT to improve existing processes (Ouwens et al., 2005; Wendt and Löcherbach, 2011).

Nevertheless, all concepts share the idea of a more patient-centered healthcare service provisioning along the complete patient care pathway trying to overcome the current, fragmented healthcare industry in terms of cooperation, information sharing, and accounting. Yet, in practice such patient-centered coordination concepts often fail because of the healthcare system's features, e.g. customers do not pay for services⁵ and fragmentation of healthcare providers. Thus, in practice all three presented concepts either constrict patient access or do not involve all necessary healthcare service providers along the complete patient care pathway. For example, only patients from a dedicated insurance can take advantage of precisely defined healthcare service providers. As soon as the patients see a physician that is not part of the network, the coordination advantage is lost.

⁵As described in Section 2.1, in the healthcare domain mostly insurances pay for healthcare services provided for patients, i.e. customers.

Even though none of the concepts captures the idea of an HSN that forms along the patient care pathway, the case management approach can serve as an initial conceptual idea. Since the case management approach aims at coordinating information between all stakeholders involved in supplying healthcare service for patients, the concept provides good prerequisites for a patient-centered coordination service. In theory, case management has great potential in terms of effectiveness, efficiency, and quality of patient care through comprehensive, early involvement of all stakeholders along the patient care pathway (Bodenheimer, 2008; Wendt and Löcherbach, 2011). It promises cost savings from avoided hospital re-admissions, reduces lengths of inpatient treatment, and fewer unnecessary treatments by simultaneously enabling more necessary treatment, i.e. less healthcare service overuse, misuse, and underuse. Since the work at hand particularly looks at stroke-specific care coordination, the following subsection describes post-acute stroke treatment in more detail.

3.3.4 Post-acute Stroke Treatment

A stroke or cerebrovascular accident is a decline of brain functions caused by a lack of blood flow due to a blockage (ischemia) or internal bleeding (hemorrhage). If not treated quickly, this may cause permanent neurological damage, such as loss in cognition, vision, speaking abilities and motor functions, or even death. The quicker blood flow is restored or internal bleedings are stopped, the better are chances of survival and the fewer are resulting neurological impairments. Therefore, many approaches deal with improving acute treatment to treat patients as quickly as possible. For example (Ziegler et al., 2011), (Audebert, 2006), and (Lewis et al., 2006) have accomplished to significantly lower death rates.

However, more than 60% of the stroke patients survive disabled and are in need of long-term care. These long-term medical implications involve various healthcare stakeholders along the complete care pathway (Adamson et al., 2004; Lloyd-Jones et al., 2010). Even if patients suffer from a rather mild stroke, subsequent care processes generally involve physical, occupational, and speech therapy (Kjellström et al., 2007; Jones and Riazi, 2010). In case of a severe stroke, patients often do not regain full physical and cognitive abilities after rehabilitation (Jones and Riazi, 2010). Often, they are in need of constant, professional care, either in nursing homes or – on rare occasions – at home (Kolominsky-Rabas et al., 2006). Only if it is a transitory ischemic attack (TIA), which is a temporary stroke, patients usually do not face such drastic consequences with respect to their physical and cognitive abilities (Schlote et al., 2008). Nevertheless, for each stroke survivor, secondary prevention is equally important because people that have had a stroke are most likely to have

another stroke (Kjellström et al., 2007; Schlote et al., 2008; Langhorne et al., 2011; Grube et al., 2011).

The "ideal" stroke care pathway is illustrated in Figure 3.3. It is divided into three different phases: 1) acute care, 2) post-acute inpatient care, and 3) post-acute outpatient care. These phases are not defined by the time elapsed since the stroke incident but rather by the health state of the patient. During the first phase, the patient receives emergency treatment and is admitted to the hospital. Here, in the case of a stroke, the treatment aims at saving the patient's life and involves mostly process coordination with strict timely restriction because the faster the patient receives the adequate acute treatment the better the outcome (Kjellström et al., 2007). Whereas the acute inpatient treatment aims at saving the patient's life, the post-acute care aims at allowing the patient to regain cognitive and motor skills and prepare them for reintegration into the personal environment (Lloyd-Jones et al., 2010). These therapies and interventions have to be adapted individually and the rehabilitation is often located at different sites, for example the patient home, the hospital, or the office of a specialist (Schwamm et al., 2005). From a clinical perspective, the inpatient treatment is divided into four stages. Stage A is defined as acute treatment and stages B, C, and D signify different rehabilitation stages depending on stroke severity (Barzel et al., 2008). Patients with large deficiencies in cognitive and motor skills – usually patients suffering from a severe stroke – are treated in stage B. Patients with average and small deficiencies are treated in stage C and D, respectively. Ideally, a stroke patient sequentially passes through these four stages during rehabilitation or even omits treatments in stage B and C because of good health.

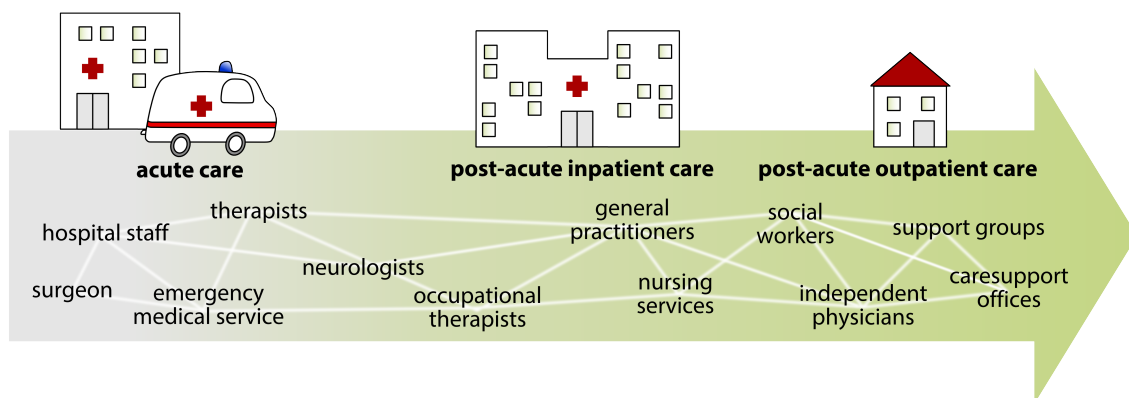


Figure 3.3: Illustration of the "ideal" stroke care pathway and the involved health-care stakeholders with schematic connections between them.

For the "ideal" stroke patient, who received the successful acute treatment, the post-acute care begins immediately in the inpatient settings and continues in the outpatient settings. Sometimes it involves life-long changes, rehabilitation activities, and secondary prevention (Schwamm et al., 2005; Kjellström et al., 2007). Therefore, stroke is similar to most chronic diseases, for example congestive heart failure (CHF)

or constructive obstructive pulmonary disease (COPD), which start out with an acute event and require a long-time, often even life-long, treatment (Bodenheimer, 2008). Particularly, the post-acute phase, in which many inpatient and outpatient healthcare service providers need to cooperate for the optimal stroke treatment, induces a complex stroke service coordination (Barzel et al., 2008). If a coordination service concept manages to improve the information flow in such a complex setting, it can be adapted to other settings, i.e. chronic diseases (Bodenheimer, 2008).

As indicated by Figure 3.3, there are many healthcare stakeholders involved along the complete stroke care pathway and, particularly, in the post-acute treatment. Apart from the patient, professionals are involved such as general physicians, specialized physicians, nurses, social services, physiotherapists, occupational therapists, speech therapists, and psychologists as well as informal caregivers such as family, friends, and acquaintances. Due to their specialization, particularly the healthcare service providers in this setting are used to working autonomously and separately from each other. Furthermore, family, friends, and even acquaintances are confronted with a new situation they rarely have any experience with. This leaves a considerable burden for the involved informal caregivers (McCullagh et al., 2005; Smith et al., 2008; Washington et al., 2011).

As within most chronic conditions, one of the most-known characteristics of stroke patients and their families is their need for information (Washington et al., 2011; Wachters-Kaufmann et al., 2005). This need arises from the lack of knowledge about stroke in general and the ways to deal with the new situation. Stroke patients especially lack medical information, information on how to gather resources and continue care at home, and information about the numerous healthcare service providers available (Wiles et al., 1998). Particularly secondary prevention, i.e. preventing another stroke, through minimizing stroke related-risk factors, is challenging for stroke patients (Davoody et al., 2012). For it to be effective, the patients need information about risk factors like hypertension, diabetes, smoking, alcohol use, or obesity (Lloyd-Jones et al., 2010). Despite its societal importance and impact on the global chronic disease burden, there is little literature on post-acute stroke management overall. The literature is yet dominated by prevention and early-care treatments (Murray et al., 2007). According to Murray (Murray et al., 2007), the existing post-acute stroke-related literature is mostly of medical nature discussing effectiveness and predictors of different stroke treatments, medical procedures, or medications.

3.4 Summary

This section introduced the service development fundamentals that are relevant for this work, i.e. the methodology and related coordination service concepts. It discussed the advantages and shortcomings of the state-of-the-art service approaches and introduced the designated methodologies for the service engineering and service research. In addition to the methodology, this section assessed and classified state-of-the-art coordination concepts that are currently in practice to improve care coordination.

The most common service engineering approaches (Shostack, 1982; Scheuing and Johnson, 1989; Edvardsson and Olsson, 1996; Ramaswamy, 1996) have been compared, and Ramaswamy's approach was singled out as being the most feasible regarding systematization, customer integration, and usage in practice. This is in line with the findings of (Fährnich and Meiren, 2007) from 2006. In the past years, several novel service engineering approaches that focus on specific use cases, like person-oriented services (Menschner and Leimeister, 2012) or telemedicine services (Peters and Leimeister, 2013), have been developed. Yet, Ramaswamy's approach maintains several advantages and was, therefore, chosen as the used engineering method. Because ICT plays an important role in the service, Ramaswamy's service engineering approach is enhanced by expanding the service concept evaluation phase with evolutionary prototyping (Tate, 1990). Thus, service design and system engineering are not sequential development steps but rather interdependent processes allowing to successfully integrate ICT in existing healthcare processes. This interdependent development is a distinct difference with respect to state-of-the-art service engineering approaches. Even though there are numerous existing service engineering approaches, none of the ones that have been validated in practice, take the healthcare domain characteristics into account. Thus, healthcare domain characteristics, i.e. that patients are often rather consumer than customer, were considered when devising the service engineering methodology.

Apart from the engineering method, this section also introduced the research methodology for validating the essential characteristics of the coordination service, i.e. studying Research Question 2. Due to the applied nature of investigating a coordination service with a long-term perspective, the case study was chosen as research methodology. Consequently, in order to identify requirements and functions of such a coordination service, this involves analyzing documentation, administering surveys, interviews, and workshops, observation, and shadowing. Since case-specific effects possibly influence external validity and generalizability, this has to be taken into account when assessing the implications of the results (Yin, 2008). As in field experiments in general, this influence cannot be fully controlled for or eliminated.

Chapter 4

Service Development Results

In this chapter the coordination service's development is described. It relates to Research Question 2 that investigates the characteristics of a service that improves care coordination along the patient care pathway. To achieve results that are of theoretical relevance while also being usable in practice, a general patient-centered coordination service concept was developed while the focus was put on post-acute stroke treatment. Yet, as described earlier (Section 3.3.4), stroke is a complex disease involving numerous healthcare service providers and long-term treatment. Using the engineering and research methodologies described in Chapter 3, the coordination service was developed and its functions were validated, respectively. A service engineering method based on Ramaswamy (1996) was employed to support the development of the coordination service for post-acute stroke stroke treatment. For validation of a coordination service, the so called *stroke manager service*, a case study approach was used which consisted of qualitative and quantitative evaluation methods¹.

Goal of the coordination service is to improve information flow in an HSN to improve its healthcare service quality, whose correlation was argued in Chapter 2. Since the work at hand seeks to provide theoretical and practical contributions, an applicable coordination service was developed instead of finding the – in theory – optimal coordination mechanism. As postulated by Page (2003) an incremental approach to improving healthcare service coordination is advantageous because it copes best with the contemporary fragmented service provision in healthcare. With the devised service engineering method, the service's ICT and corresponding processes could be designed to incrementally improve existing structures and processes. Research Question 2 generally targets coordination service characteris-

¹As stated in Section 1.3, the devised methodology and results of the evaluation that validated the general approach, requirements, and the coordination concept in terms of structure and process have already been published in excerpts in (Hartmann et al., 2011; Görlitz et al., 2012; Görlitz and Rashid, 2012b; Görlitz and Görlitz, 2012; Görlitz and Rashid, 2012a; Görlitz et al., 2012)

tics, which improve information flow in an HSN, particularly, reduce information asymmetries between involved stakeholders. To answer this question exhaustively, it is split into two sub questions that allow a more detailed consideration.

Even though improving coordination in healthcare is a well-known issue, there are few publications that deal with inter-organizational information management (Winter, 2009). Consequently, when investigating the coordination service's characteristics, its requirements have to be elaborated first. In addition, there is no common understanding of how to measure whether such a coordination service is beneficial (see 2.3 and 3.3 for the theoretical and applied perspective, respectively). Thus, the first sub question investigates the coordination service's requirements and performance standards.

RQ 2.1 What are the coordination service's requirements and performance standards for measuring its effects?

In addition to this first, more theoretical part of Research Question 2, transforming the requirements and performance standards to a real-world application have to be investigated. Therefore, the second part of Research Question 2 deals with particular functions that the coordination service, especially, the *stroke manager service*, needs to comprise.

RQ 2.2 What are the coordination service's functions based on the identified requirements?

The sub questions stated above were addressed during service design phase. Individual stages of the service design phase are illustrated in Figure 4.1. The figure shows the cyclic, customer-centered service engineering method of Ramaswamy (1996) as a framework methodology. Because of expectantly high degree of ICT usage, the additional evolutionary prototyping (Tate, 1990) approach was incorporated in the service design phase to achieve technically sound solutions. This provided a mechanism to directly transform gathered requirements of the coordination service into software and hardware while improving ICT gradually. This practice allowed fast design, build and adaptation of the envisioned ICT-infrastructure. Furthermore, Figure 4.1 also shows the single case study evaluation techniques as described by Yin (2008) that are used in different service engineering stages. Since the designed service with the devised ICT is specifically tailored for the healthcare domain, guidelines for a good evaluation practice in health informatics (GEP-HI) (Nykänen et al., 2011) are taken into account during the design phase. This means that, for example, ethical and legal issues are taken care of in advance or health risk analyzes are performed.

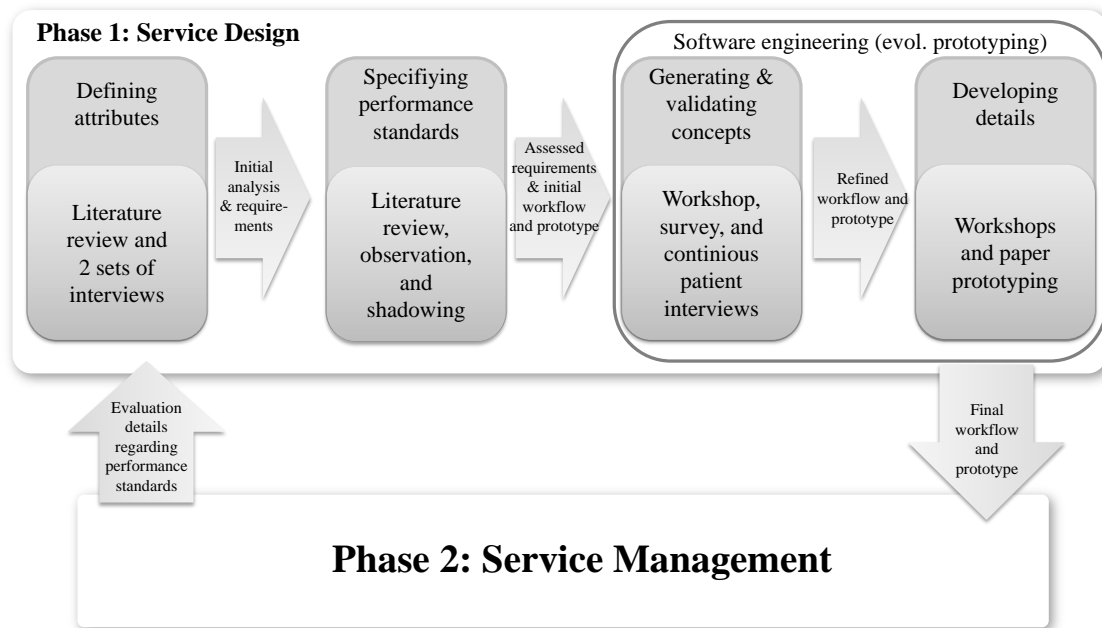


Figure 4.1: Illustration of combined service and software engineering approach to develop the stroke manager service, which is based on Ramaswamy (1996) and Tate (1990)

In the next sections, the service development is presented according to the design stages depicted in Figure 4.1: 1) Defining the service’s attributes; 2) Specifying performance standards; 3) Generating and evaluating different service concepts; and 4) Developing the service’s details. To validate the identified requirements, these stages were embedded in a case study scenario as described in Section 3.2, of which different data sources are also shown in Figure 4.1. In the first section, the first part of Research Question 2 – the coordination service’s requirements and benchmarks – is investigated. For these requirements, service attributes were defined using an extensive literature analysis to identify state-of-the-art approaches and two sets of qualitative interviews to derive requirements for an improved post-acute stroke manager service. Benchmarks were specified by state-of-the-art stroke literature, observations, and shadowing, thus validating and specifying the initial requirements. In the second and third section, respectively results of the third and fourth service design stage are presented. These stages were majorly driven by expert workshops, focus groups, continuous interviews with primary users of the ICT-structure, and a survey. The evolutionary prototyping, which was used for the ICT-structure of the stroke manager service, came into play at this point of the service design. In these sections, the stroke manager service concepts and the developed details are presented in more detail, which relates to the second part of Research Question 2, in which the service’s functions and characteristics are investigated. In the summary, lessons learned and implications for service engineering in healthcare are discussed in addition to summarizing the findings.

4.1 Service Attributes and Performance Standards

In this section, the coordination service's attributes and corresponding performance standards are defined and specified, respectively. According to the methodology, they were investigated in the first two stages of the design phase using existing literature, semi-structured interviews, and on-site observation as well as shadowing. Investigating the attributes and performance standards relates to the first part of Research Question 2, which focuses on the coordination service's requirements and evaluation metrics. Going along with the initial motivation, from the beginning on there were already the following three assumptions regarding the requirements of such a service:

- The coordination service needs to be **patient-centered** in terms of patient involvement (see Section 2.3 for a precise definition);
- The coordination service needs to be **centrally** administered;
- The coordination service needs to be of **socio-technical** nature.

The first assumption targets the long-term treatment of patients suffering from chronic diseases. Based on findings from Porter and Olmstead Teisberg (2006), Kaplan and Porter (2011), and Sun et al. (2013), it assumes that the coordination service needs to be patient-centered to allow active patient involvement for an effective support along the complete patient care pathway. This means that taking the patient's needs into account is essential for high quality care, that the healthcare services should be individually performed, and that family and friends who the patient relies on should be involved (Haux, 2006; Berwick, 2009; Gianchandani, 2011; Wilson et al., 2012; Sun et al., 2013). The second assumption is about the organization of the service. It states that the service needs to be centrally administered because otherwise it cannot effectively improve the information flow in the contemporary fragmented healthcare system. In small networks, a 1:1 communication is sufficient to achieve coordinated processes, but as the number of stakeholders in a network grows, relaying information causes too much overhead (Gericke et al., 2006). A central entity that gathers and distributes the information appropriately is more efficient. The third assumption is derived from the state-of-the-art characterization of patients suffering from chronic diseases. It accompanies the first assumption of needing a patient-centered healthcare. For example, Jones and Riazi (2010) and Fichman et al. (2011) state that patients are in need of individual support and, therefore, cannot be simply cared for by an automated service – at least with the contemporary ICT.

The coordination service's requirements – including the preliminary assumptions – were investigated in a case study setting using quantitative and qualitative meth-

ods (Yin, 2008). Since the service development has an exploratory character, quantitative methods were too restricting because they aim at evaluating hypotheses about existing structures by investigating a large number of cases. More qualitative methods were necessary because the service requirements – particularly the already made assumptions – could not be stated as verifiable hypotheses. Thus, the service requirements were postulated after desk research, i.e. state-of-the-art literature, medical guidelines, and internal documents, and after administering semi-structured interviews. Then the requirements were translated to service concepts and a real-world implementation, which can then be evaluated quantitatively. Furthermore, this development process aided the hypotheses and theory building because it provided more insights into the healthcare processes.

Since the requirements differ according to the service customer, first, the key customers had to be identified. In the HSN, a large group of stakeholders qualifies as being customers (for details see Section 2.1). Particularly, patients, their care-giving relatives and all the different kinds of healthcare service providers were investigated. This investigation is presented in the next subsections. First, the key customers are presented and their identified needs are described. Second, the specified service attributes are presented, which are based on the customer needs. Furthermore, the initial service requirements are presented, which are based on the relationship between the identified needs and specified attributes. The third subsection presents the stroke-specific attributes that served as performance standards for the stroke manager service, i.e. the stroke-specific coordination service. They have been transformed from the general requirements and attributes that have been specified.

4.1.1 Stakeholders and Customers

Due to the characteristics of the healthcare domain (see Section 2.1), the first step of all service engineering methods – identifying the key customers, determining their needs and expectations, and specifying the service’s attributes accordingly – could not be applied unambiguously because it is not necessarily expedient. If the patient is the customer but does not pay for nor freely choose the service, satisfying the patient’s needs and expectations might not be enough. Since a precise understanding of the key customer(s) is the basis of all service engineering frameworks and, particularly, of the pursued service engineering framework by Ramaswamy (1996), all possible stakeholders in a healthcare service network were investigated.

Instead of describing the numerous scenarios in which the identified stakeholders interact with each other, exchange information, and might qualify as customers for the stroke manager service, in the following paragraph the stakeholders are characterized using personas. Personas are a concept from marketing and user-centered

software design in which fictional characters are created to represent different types of people (Cooper, 1999). They are created based on demographic studies about the target group from which demographic facts such as average age, gender, or common characteristics are distilled. In the design phase, using personas is more engaging than using scenarios because they focus the attention more on design aspects (Pruitt and Grudin, 2003). Its effectiveness with respect to different stages of the design process have been shown and quantified by Long (2009). Figure 4.2 shows the involved stakeholders and potential customers of the stroke manager service in an HSN. The interaction between stakeholders are characterized by arrows denoting possible information exchange at one point of time along the complete patient care pathway.

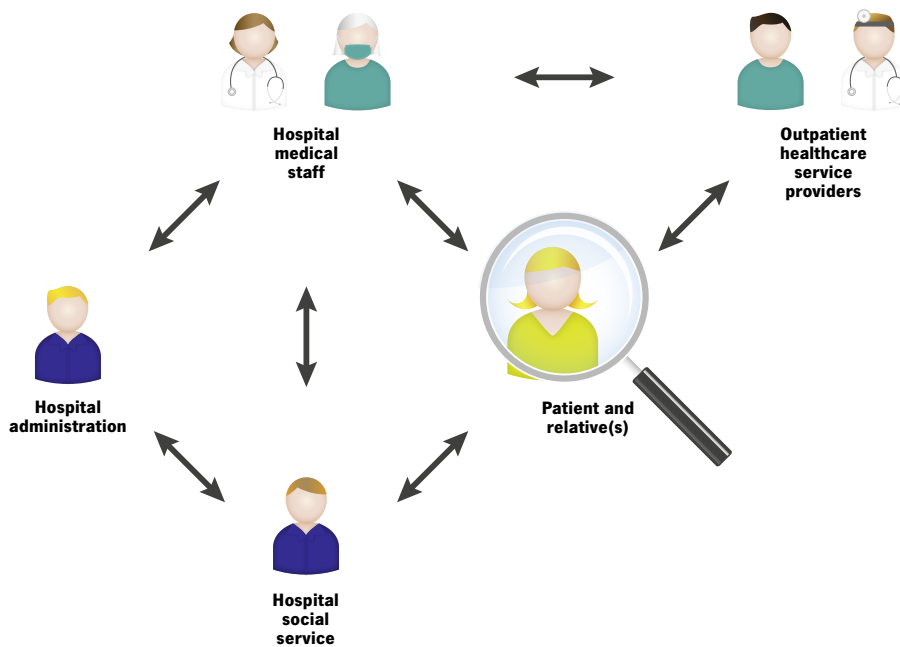


Figure 4.2: Illustration of the key stakeholder groups in an HSN, in which the arrows signify their usual interaction pattern.

At the center is the patient because without a patient, there is no need for health-care services (Berwick, 2009). Average surviving stroke patients in western countries, for example in Germany, are male, retired, about 72 years old, and live with their wives in a rural area (Heuschmann et al., 2010). After inpatient rehabilitation, they are left with slight deficits regarding their cognitive and motor skills (Adamson et al., 2004), which requires them to visit a general physician and therapists regularly (Grube et al., 2011). Surviving stroke patients are at risk of another stroke and they need to alter their daily living routine for secondary prevention, i.e. regularly measuring blood pressure and taking medicine on a daily basis (Hensler et al., 2007).

For both, rehabilitation and secondary prevention, they need coordination support and information, respectively (NSA, 2006). Even though the patient physically is a different person than the care-giving relative, they somewhat act as a unit. Either the patient suffers from a severe stroke needing constant support of a care-giving relative or the patient suffers from a mild stroke with few to no consequences. In the first case, the caregiver takes control and does most of the information exchange for the patient, hence needs to be involved as much as the patient. In the second case the patient handles most of the information exchange. Thus, patient and care-giver form the stakeholder group *patient and relative*.

For the acute stroke treatment, the emergency medical service involving paramedics, emergency physician and dispatcher is most important. However, for the post-acute treatment they are of low interest because they do not directly benefit from a post-acute coordination. They might only make use of a precise feedback due to the more structured post-acute processes. In contrast, the stakeholder groups of the inpatient, acute stroke treatment are of high interest. Doctors, surgeons, nurses, therapists, psychologists, social workers and other healthcare occupations in a hospital are involved during the acute treatment and inpatient post-acute treatment, e.g. inpatient rehabilitation. As shown in Figure 4.2, they are clustered into *medical staff*, *social services* and *hospital administration*. All these groups are associated with one hospital – one organization – but nevertheless they often do not share their information or have access to the same ICT (Haux, 2006). In Section 3.3.4 the characteristics of the post-acute inpatient and outpatient treatment have been presented. Among the discussed approaches to improve the information management during the post-acute phase is case management, which aims at improving the information sharing between *medical staff*, *social services* and *hospital administration*. Improvements have already been shown in a single hospital without considering other organizations (Crawley, 1996). The involved inpatient healthcare service providers benefit from a better information exchange to improve inter-disciplinary cooperation, adjust workload balance, and even simply to allow appreciating the provided healthcare service's quality.

For the most part of the post-acute stroke treatment, *outpatient healthcare service providers* such as general practitioners, resident specialists, registered therapists, ambulatory services and pharmacists or facilities such as nursing homes and special care homes are involved. They are characterized as heterogeneous fields of specialization that suffer from the fragmentation of the healthcare industry alike (Bodenheimer, 2008). For example, the occupational therapist works alone but depends on the general practitioner's referral. In this situation, apart from the letter of referral, the therapist benefits from current patient data to adapt the therapy. However, compiling this information is additional work for the general practitioner, thus it is rarely provided. These information asymmetries between different healthcare

service providers, particularly outpatient ones, are symptomatic in the healthcare domain (Mooney and Ryan, 1993; Smith et al., 1997). Therefore, apart from *patient and relative*, *outpatient healthcare service providers* benefit directly from a service that facilitates the information flow between the different healthcare service providers.

Furthermore, three other groups of healthcare stakeholders have to be considered: policy makers, such as public health authorities or other legal institutions; payers, such as health maintenance organizations, health insurances, or pension funds; and healthcare service contractors, such as pharmaceutical industry or manufacturers of medical devices. However, they are not necessarily customers because they would not benefit from a more efficient coordination directly. Healthcare service contractors might even benefit from uncoordinated healthcare service provision because this often results in overuse of some services (Johnston, 2004). Policy makers and payers benefit indirectly because they generally want to increase healthcare quality for patients. Especially, if this is possible with equal or lower financial expenditures. For these two stakeholder groups, particularly for the payers, their requests regarding a coordination service are similar to the group of *patient and relative*. None of these stakeholder groups qualify as primary customers, albeit they might be acquired as co-funders once the impact of the service is established.

4.1.2 General Requirements

After the key stakeholders and possible customers, i.e. *patients and relatives*, *medical staff*, *social services* and *hospital administration*, and *outpatient healthcare service providers*, have been identified, the service requirements, particularly the service attributes, could be determined. For that reason, the key stakeholders' needs and expectations regarding a coordination service in an HSN were investigated. These expectations represent general service requirements with respect to the healthcare delivery, i.e. process and structure (see Section 2.1.2). Regarding the information exchange in healthcare, there are strong legal regulations that vary extremely between different countries, sometimes even between different states of one country. Since the legal requirements might contradict the general service requirements for the coordination service's process and structure, they were taken into account early in the service design.

Following the methodology described in Section 3.2, the state-of-the-art literature in post-acute treatment was compared to the available case-specific documentation such as documents, medical guidelines, and general post-acute management practices. Furthermore, semi-structured interviews, on-site observation, and shadowing were applied to substantiate the documentation analysis. Two sets of semi-

structured expert interviews were administered with a sample of the key stakeholder group, whose characteristics were described in the previous section.

The first set of interviews focused on the general information deficits of stroke patients and their caregivers. On the patient side, information deficits are acknowledged as one of the key obstructions in coordination (Bodenheimer, 2008). When focusing on these information deficits, which is advocated by the patient-centered approach (Anderson and Knickman, 2001), it seems natural to consider the Internet as a powerful source to compensate these shortcomings (Cross, 2008). In fact, there is much evidence that patients use the Internet exceedingly to find health information (Diaz et al., 2002; Kummervold et al., 2008). Therefore, the first investigation direction aimed at identifying service attributes that leverage the health 2.0 phenomenon, i.e. healthcare stakeholders which use web tools to communicate and cooperate. It investigated the Internet's impact regarding information provision and information exchange between *patients and relatives* because it might serve as a remedy for the information deficits and poor service coordination (Cross, 2008). The rationale behind this is the advent of health 2.0 or medicine 2.0, which describes healthcare stakeholders using web 2.0 tools, e.g. blogs, wikis etc., for collaboration, education, and more personalized healthcare (Eysenbach, 2008; Hughes et al., 2008; Van de Belt et al., 2010). If healthcare stakeholders were relying on health 2.0 tools, the well-informed and empowered patients provide efficient coordination in an HSN themselves. Therefore, the stakeholder's view on stroke patient's and their care-giver's information deficits and the existing information on the Internet were investigated in the first interview set.

Ten persons, two neurologists, four care-giving relatives, two home nurses and two members of a German Stroke Foundation, were asked about their view on health information on the Internet during the course of post-acute stroke management. The ten people were interviewed by the same interviewer using an interview guide which covered general questions relating to the interviewees themselves, questions about online health information, and specific questions about existing online health offerings. The question put a particular focus on privacy or data ownership and the reliability of health information on the Internet, which are identified as critical issues in (Hughes et al., 2008) and (Craigie et al., 2002; Eysenbach et al., 2002), respectively. Furthermore, among others, (NSA, 2006; Paraskevas et al., 2011; Wissel et al., 2011) suggest that the online health information will not be sufficient for the complex stroke care. Sample questions are shown in Table 4.1, and the full interview guide can be found in the appendix A.1.

After transcribing, decoding, and analyzing the interviews according to Mayring (2010), they confirmed the initial doubt that online health information is not a valid option for post-acute stroke care. Due to three major reasons, stroke patients can

Sample question	Category	SF	P/R	HS
What are the goals of your website?	General	x		
How long are you in need of care or give care regularly?	General		x	
How often do you use the Internet to get health information?	Information	x	x	x
Which criteria are important for online healthcare information?	Information	x	x	x
Where should a health portal rather put the emphasis on: information provision, exchange of experiences via online communities or product and service offers?	Online health	x	x	x
What kind of health services or products would you like to buy/sell online?	Online health	x	x	x

Table 4.1: First interview set sample questions with corresponding category and interviewee asked (SF = member of the stroke foundation, P/R = patient or relative, HS = healthcare service provider). Full set of questions can be found in Appendix A.1

not easily exploit the Internet by themselves. First, due to their average age and stroke repercussions, stroke patients are generally not capable of regathering and processing the information. In addition, the common primary care-giver is over the age of 60 and female (Heuschmann et al., 2010) and has rarely any experience using computers let alone the Internet at all (Infratest, 2010). This is undermined by contradicting statements of one care-giving relative that said "actually, I do not know what I need the Internet for" and specified later during the interview "the Internet is a good thing, but rather something for the upcoming generation." Second, all interviewees agreed that post-acute stroke care is of such individual nature that it is almost impossible to coordinate the variety of available healthcare services effectively for non-professional patients having no experience in the field of stroke care. Patients and care-giving relatives need "individual" information regarding stroke itself, available healthcare services, and administrative regulations. According to the interviewees, at the time being, these information are not available in sufficient quality via the Internet. Third, privacy, liability, and validity issues regarding online health information were reported by all interviewees. One care-giving relative reported that on some websites "there are such strange terms," which makes her fail to believe that the content is trustworthy.

As long as the three issues stated in the previous paragraph are not resolved, online health information will not be a primary source of information but rather provide supplementary material. Since the literature's doubts concerning the effectiveness of online health information for patients have been confirmed in the first set of interviews, a service that improves coordination in an HSN cannot solely rely

on health 2.0 tools. It rather needs to intervene in the existing healthcare processes along the complete patient care pathway.

To postulate general requirements for such a service, a second set of interviews was administered to gain more insights into the current post-acute stroke management processes. For this set of interviews, apart from patients and relatives, healthcare service providers were also interviewed. Twelve persons (two general practitioners, two neurologists, two persons from ambulatory care, two stroke patients, two care-giving relatives and two therapists) were interviewed to create an accurate process model and to identify the involved stakeholders' roles, interfaces, resources and information exchange. These interviews have also been administered by one interviewer using an interview guide, which was based on state-of-the-art literature, and included confirmatory as well as exploratory questions. The interview guide covered questions relating to stakeholder's role in the HSN, the interfaces to or used resources of other healthcare stakeholders and the existing information exchange from their perspective. In detail, the questions in the category roles aimed at confirming that the stakeholders perceive themselves as they are characterized in theoretic models of the post-acute treatment. Questions from categories interfaces/ resources and information exchange were more of exploratory nature. On the one hand, with the provided answers, the information barriers, which have already been identified by others, were investigated more closely. On the other hand, additional issues regarding the information exchange in an HSN were looked for. Sample questions are shown in Table 4.2, and the full interview guide can be found in the appendix A.2.

Similar to the first set of interviews, the second set of interviews was transcribed, decoded and analyzed with appropriate methodology proposed by Mayring (2010). Analysis confirmed the findings of state-of-the-art literature. The major problem are the information barriers between different healthcare stakeholders. For example, one general practitioner stated that he "would greatly appreciate a dedicated person in the hospital, whom he could contact to get patient data" because he never gets hold of a responsible person when calling the hospital. Curiously, specialized neurologists reported the same problems when trying to get specific information from general practitioners. All the interviewed healthcare service providers reported that they are missing information to adequately treat the patient, even though they know that these information are often gathered by other healthcare service providers or sometimes even the patients themselves. Nevertheless, the other healthcare service providers or the patients are not willing or able to provide these information. This results in suboptimal resource allocation for the healthcare service providers. Information asymmetries, especially between different healthcare sectors, i.e. inpatient and outpatient treatment, are one of the major obstructions to effective coordination that is important for *patient and relative*.

Sample question	Question category	GP	N	A	T	P/R
Which therapists did you go to?	Roles					x
What are the differences between inpatient and outpatient therapy?	Roles	x	x	x	x	x
Do you cooperate with therapists or nursing services?	Roles	x	x			
What information do you need to provide a high-quality service and who provides it?	Interfaces/ resources	x	x	x	x	
Are there gaps between inpatient and outpatient care? If yes, which?	Interfaces/ resources	x	x	x	x	x
How do you exchange information/ data with other healthcare providers?	Interfaces/ resources	x	x	x	x	
When were you informed about the next steps of your ongoing therapy?	Information exchange			x	x	x
Do you think more information exchange between GP and therapists is needed?	Information exchange	x	x	x	x	x

Table 4.2: Second interview set sample questions with corresponding category and interviewee asked (GP = general practitioner, N = neurologist, A = ambulatory care, T = therapist, and P/R = patient & relative). Full set of questions can be found in Appendix A.2

When discussing ideas of sharing more information among the *outpatient health-care service providers*, interviewees responded that there are no incentives to take care of others' activities. One physician answered that he would like to share information if "the cumbersome compilation of the needed information would be rewarded, for example financially or by less effort in other areas." As expected, some of the interviewed stakeholders raised the idea of the benefits of homogeneously used information and communication technology that allows easy data exchange. "Instead of carrying my medical report around, doctors should be able to access them with their computers directly" complained one patient. This view was shared by providers, whereas they also highlighted issues regarding data security and missing comparability of software. In contrast to possible positive effects, the downside of using ICT was also emphasized by *patients and relatives*. They fear that using too much ICT would decrease individual contact to healthcare service providers, which is "essential" because otherwise they would not feel "comfortable."

Overall, the problems regarding the information management in an HSN caused by the fragmented healthcare system, which have been identified in the literature (see for example (Porter and Olmstead Teisberg, 2006; Bodenheimer, 2008; Kaplan and Porter, 2011)), have been confirmed. Moreover, the interviews undermined

the approach of this work that proposes a coordination service for patients suffering from a chronic disease. One therapist testified that "the current system would greatly benefit from something or somebody that supports the information exchange independent of existing information systems and organizations." All of the interviewees agreed that such a service is useful, and that such a service can provide the right incentives for all the involved stakeholders to cooperate. In an deductive manner (see Mayring (2010) for details), several requirements regarding such a service have been formulated. In the following paragraphs, the essential structure (S1-S6), processes (P1-P6), and legal restrictions (L1-L5) are stated, which were distilled from state-of-the-art literature and the semi-structured interviews.

Requirement S1: Device and location independent access;

Requirement S2: Connection to existing data(bases);

Requirement S3: Workflow management system;

Requirement S4: Mobile component;

Requirement S5: Connection to telemedicine devices;

Requirement S6: Hardware security measures.

The underlying ICT needs to provide device and location independent data access because it needs to be accessed from different locations and from different stakeholders in different phases of the patient pathway (S1). In line with the findings of Mäenpää et al. (2009), the ICT also needs to allow incorporating existing databases (e.g., hospital information systems) easily (S2). Otherwise multiple or corrupted data storage might occur. Due to numerous involved stakeholders and their interconnections that the coordination service needs to administer efficiently, a workflow management system should be incorporated (S3). In order to support patients and their relatives as much as possible (i.e., while being at home or on the road), the other structural requirement is a mobile component that can be used by patients and relatives (S4). The ICT should provide interfaces to connect telemedicine devices or assistive technologies (S5) and comprise sophisticated hardware security measures (S6), due to the vulnerable healthcare data that is handled. In addition to these structure requirements, the following process requirements have been identified.

Requirement P1: Affect the complete patient care pathway;

Requirement P2: Person-oriented;

Requirement P3: Home visits;

Requirement P4: Contact to all involved stakeholders;

Requirement P5: Sophisticated ICT support;

Requirement P6: Patient consent.

Regardless of the service's structural requirements, i.e. used ICT, the coordination service has to take place along the complete patient care pathway which ranges from acute inpatient treatment to post-acute outpatient treatment (P1). In Section 3.3.4 this pathway is described in more detail. For example, information that was gathered during the acute phase might be important for the stakeholders involved in the rehabilitation (Bodenheimer, 2008). Since people are individual and – at least up to date – do not trust a solely ICT-based system, the service has to be person-oriented to consider the individual patient's care pathway (P2). Due to these individual needs and the possible immobility of patients, occasional face-to-face home visits are necessary (P3). To access all necessary information, the service needs to contact all involved stakeholders of the HSN and provide incentives for them to cooperate and share their information (P4). During the requirements analysis became evident that the service needs to be supported by sophisticated ICT to operate efficiently (P5). In addition to the above process requirements, generally, the patient's consent must be acquired (P6). Patients cannot be forced to be supported, even though objectively it might be in their interest.

In addition to structure and process requirements, federal and state data protection laws or industry-specific agreements have to be considered because patient data is viewed as the most valuable personal data (Görlitz and Rashid, 2012a). These legal requirements have to be considered as early as possible during the service design phase. Their elaboration is often tedious and cumbersome, and, often, they have a great impact on structure and processes. Thus, the following legal requirements that are based on literature and interviews are postulated.

Requirement L1: Access and disclosure control;

Requirement L2: Replicable and comprehensive documentation;

Requirement L3: Few data sets;

Requirement L4: Pseudonymization;

Requirement L5: Encryption.

According to the law, access and disclosure control has to be granted for stored patient data to prevent unauthorized access to systems processing personal data and unauthorized operations on personal data during transmission, respectively (L1). Furthermore, replicable and comprehensive documentation of changes has to be provided by the ICT to ensure that data manipulation can be traced afterward (L2). To satisfy data reduction and economy statutes of the government, as few data as possible has to be collected, processed, and stored (L3). In case of data loss, the potential magnitude of its effects have to be decreased by using pseudonyms or

even anonymous data sets whenever possible (L4) and state-of-the-art encryption (L5).

When designing the coordination service structure, process, and legal requirements need to be considered (see Figure 4.3). Striking is the need for a person supporting the involved participants because of the individual situation and individual information deficits. This requires a person-oriented service or socio-technical system, which then needs a central administration to distribute the information effectively in a large HSN (Gericke et al., 2006). Therefore, the initial assumptions that the service were to be a centrally administered, patient-centered, and socio-technical service was confirmed. Moreover, additional requirements, i.e. service attributes and customer's expectations, were identified in this first service design stage. Once, these requirements have been accumulated, the service attributes and performance standards are specified to complete investigating the first part of Research Question 2.

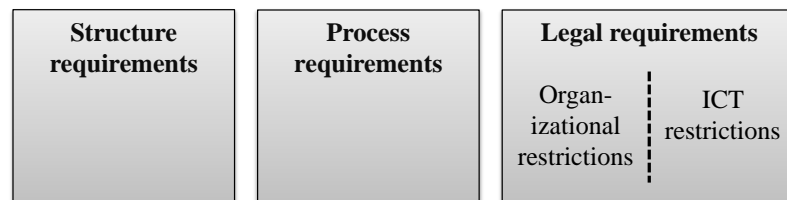


Figure 4.3: Overview of the three requirement groups for the coordination service.

4.1.3 Stroke-specific Performance Standards

Based on identified key customers' expectations, which are expressed by structure, process, and legal requirements, the service can be developed accordingly. From a service engineering perspective, this is sufficient, however, the customers' "needs" and identified requirements do not serve as quantifiable measure. For example, the degree of person-orientation, which is one of the process requirements (P2), cannot be measured. Therefore, in stage two of the service design process, performance standards, i.e. quantifiable metrics, are looked for to allow a valid evaluation of the service effects in the management phase. A valid evaluation framework for the service's effects is needed in Part III, in which Research Question 3 is investigated. It deals with the service effects in an HSN. In Chapter 5 the service evaluation methodology is introduced, which is based on the evaluation framework specified in this section. Consequently, in Chapter 6 the results that are in turn based on the evaluation methodology are presented.

In order to develop metrics that serve as quantifiable determinants for health-care service quality in an HSN, state-of-the-art literature was consulted and findings

HSQ category	Metric
Healthcare delivery quality	1) patient self-management competences (PSMC)
	2) timely utilization of healthcare services (TUHS)
Patient health	1) final patient outcome indicators (FO)
	2) intermediate patient outcome proxies (IO)

Table 4.3: Identified general metrics for measuring HSQ in an HSN, which are applicable as performance standards for the coordination service.

double-checked regarding their usability in practice during on-site observation and shadowing. Particularly, in networked settings, e.g. in HSNs, HSQ evaluation is not solely outcome-based, i.e. focused on patient health. As already argued in Section 2.1.2, it also involves evaluating the existing structures and processes, which are described as healthcare delivery quality (Donabedian, 1966, 1988). In Table 4.3 general metrics for the coordination service are shown separated into the two HSQ categories. Whereas metrics of healthcare delivery quality incorporate structure and process determinants, determinants for patient health are outcome parameters. The former includes rather ambiguous determinants because they depend on the perspective, i.e. the viewpoint the different stakeholder. The latter is directly linked to patient health. It is generally measured in two dimensions (Donabedian, 1990): first, final patient outcome indicators, such as mortality; and second, intermediate patient outcome proxies, such as number of re-hospitalizations and scales measuring the patients' abilities.

Assigning precise performance standards for healthcare delivery quality is difficult because stakeholder groups in the HSN have different, sometimes partly divergent, needs that the coordination service should address. *Patients and relatives* rather want to receive healthcare services that they feel comfortable with than services that are necessary, e.g. there are few people that like to go to the dentist. Different healthcare service providers such as *medical staff* or *outpatient healthcare service providers* want to provide their services and, if possible, according to medical guidelines the right service at the right time. Patients suffering from chronic diseases tend to receive fewer services than they should (Langhorne and Duncan, 2001). Providing the recommended services at the right time has potential to save costs on the long run (Cameron et al., 2008). Even though healthcare payers as a stakeholder group are not part of the HSN (see Chapter 2 and Section 4.1 for details), these patient-centered performance standards also apply to their long-term goals. Therefore, applicable performance standard metrics are patient self-management competences and the timely utilization of healthcare services. The more the patient knows about a disease and its treatment, the better for all involved stakeholder groups in an HSN (Cameron et al., 2008). On the one hand, patients get more con-

cerned, improve therapy adherence, and eventually improve health quality. On the other hand, service providers benefit because patients utilize many healthcare services they did not even know of beforehand while individual patients' treatment is less time-consuming. The same applies to timely utilization of healthcare services (Langhorne and Duncan, 2001).

Whereas the healthcare delivery quality metrics are dependent on the stakeholders' viewpoint, performance standards for patient health are unambiguous. Every stakeholder group inherently wants patients to get well (Mooney and Ryan, 1993). This is in the interest of *patients and the relatives* because that is why they initially sought healthcare services in the first place. Improving patient health is also the goal of healthcare service providers. They may earn less money because they "sell" less services but in contrast they build their reputation when the patients health improves due to their services. Due to the healthcare service's characteristics (see Section 2.1.1), it is difficult to benchmark outcome against predefined, expected results as it is common practice in other industries. Donabedian (1990) states the following reasons for the problematic measurement are stated:

- **Individual people generate individual results.** There are many factors that are rooted in the patients' characteristics that might have an influence on the healthcare service provisioning. On the one hand, base characteristics for example, the patients' age, other prevailing but not diagnosed diseases, or socio-economical "confounders" influence the patient health. On the other hand, situation-dependent characteristics on the patient side, e.g. lack of cooperation, or on the physicians side, e.g. lack of symptom knowledge, also influence the patient health.
- **Few data points of the important metrics.** Particularly, in the medical field important metrics like mortality or the number of specific complications do not provide much data. If only these metrics are used as endpoints for the evaluation, the comparison between different alternatives is limited.
- **Delay of the results.** Often, the results cannot be measured immediately, but they emerge after some temporary delay. Therefore, it is difficult to attribute effects to certain treatments without a doubt.
- **Missing documentation.** For retrieving high-quality data, it is necessary that all the participants document their processes in detail. Since much of the healthcare services are very individual, such a detailed documentation is often missing.

To cope with the afore mentioned difficulties regarding performance standards of healthcare services, the work at hand did not only rely on state-of-the-art litera-

ture, available documentation, and expert interviews. To specify the defined general performance standards which are shown in Table 4.3, additional sources, i.e. observation and shadowing, were taken into account. First, stroke-specific quantitative determinants for the HSQ categories healthcare delivery quality and patient health have been derived from literature, documentation, and interviews. Then, the additional sources were used to validate them. In order to achieve this, current work processes were studied more closely. Two researchers have independently taken part in shadowing and observational sessions of the stroke treatment along the complete patient care pathway. They have shadowed – closely following involved stakeholders for several hours – certain healthcare services providers like neurologists, social service employees, and therapists as well as stroke patients while they went on with their regular routine. Moreover, they have had several observational sessions, in which the researchers stayed in one place, for example the social service office, and observed the processes independent of the person. In both settings, no interaction took place. Researchers recorded their findings independently and then synchronized them afterwards to draw conclusions regarding the suitability of the indicators. As a result, in Table 4.4 stroke-specific determinants for performance standards of the coordination service are summarized.

The distilled, relevant indicators for the two metrics of healthcare delivery quality are mainly process-based. According to Mant (2001), process indicators need to be directly linked to outcome, i.e. the patient health, to be applicable. Since the coordination service is supposed to be in place along the complete patient care pathway involving several healthcare providers, common process parameters, e.g. higher turn-over of hospital beds, are not applicable (Porter and Olmstead Teisberg, 2006; Kaplan and Porter, 2011). They aim at improving outcome of a single organizations instead of the whole HSN, which does not necessarily improve patient health. Therefore, the identified indicators are more patient-centered than focused on the healthcare service provider.

Patients need as much **information after discharge** as possible (NSA, 2006). Information provision on patient side has proven to have an effect on patient health (Cameron et al., 2008). Mainly, patients lack information about financial aids and services that are available after their hospital discharge, which often results in a suboptimal adaptation of the living conditions after discharge (Schlote et al., 2008; Cameron et al., 2008). Patients that are better informed can take better decisions and actively increase their adherence (Pound et al., 1999). Another issue is inappropriate **secondary prevention** (Kjellström et al., 2007; Bodenheimer, 2008; Hensler et al., 2007). Adherence to medical and non-medical treatment that has been prescribed after a stroke is often low (Hensler et al., 2007). For most diseases, especially for chronic conditions, there exist therapy guidelines that need to be followed and known risk factors that need to be controlled to avoid a further health deteriora-

HSQ category	Metric	Stroke-specific determinants
Healthcare delivery quality	PSMC	Information after discharge, e.g. knowledge of outpatient services (Schlote et al., 2008; NSA, 2006)
	PSMC	Secondary prevention, e.g. treatment adherence and compliance (Kjellström et al., 2007; Bodenheimer, 2008; NSA, 2006; Hensler et al., 2007; Myint et al., 2011)
	TUHS	Seamless transition, e.g. time between rehabilitation phases (Schlote et al., 2008; Bodenheimer, 2008; Hensler et al., 2007)
	TUHS	Adequate provisioning with aids (Kjellström et al., 2007)
	TUHS	Usage of healthcare services after discharge (Schlote et al., 2008; Hensler et al., 2007)
Patient health	FO	Mortality (Kjellström et al., 2007; NSA, 2006; Hensler et al., 2007)
	FO	Level of care (Heuschmann et al., 2010)
	FO	Re-occurrences (Kjellström et al., 2007; NSA, 2006; Hensler et al., 2007)
	IO	Activities of daily living (Kjellström et al., 2007; NSA, 2006; Hensler et al., 2007)
	IO	Functional abilities (Kjellström et al., 2007; NSA, 2006; Hensler et al., 2007)
	IO	Health-related quality of life (Hensler et al., 2007; Myint et al., 2011)

Table 4.4: Stroke-specific determinants for the coordination service's performance standards (PSMC = patient self-management competences, TUHS = timely utilization of healthcare services, FO = final patient outcome indicators, IO = intermediate patient outcome proxies).

tion. For example, indicators that serve as performance standards for stroke are regular blood pressure measurement, adherence to dietary recommendations, or intensity of physical activity (NSA, 2006; Grube et al., 2011). Since the coordination service is not supposed to replace any medical services, it focuses on improving the non-medical secondary prevention. Two determinants **seamless transition** and **provisioning with aids** have been identified as important for assessing transition between inpatient and outpatient settings. Indicators for the former are, for example, number of social service visits, additional screening appointments (for depression, cognitive function, swallowing function etc.), and idle time between rehabilitation phases (Grube et al., 2011). For the later, coordination performance can be measured by the amount of additional aids provided. Albeit **usage of healthcare services after discharge** correlates with information provided to patients after discharge, it is an

important indicator for the coordination service's effect. If the patients knew more about available services, they could take advantage of them, from which, on the long-run, all stakeholders of an HSN benefit.

For the stroke-specific determinants of the two patient health metrics – final patient outcome indicators and intermediate patient outcome proxies – there are numerous indicators with different means of measurement. In case of the first determinant, the stroke-specific final patient outcome indicators are commonly accepted in the literature (NSA, 2006; Kjellström et al., 2007; Heuschmann et al., 2010). The patients should have a low **mortality**, a low **level of care** needed to support their activities of daily living, and as few **re-occurrences** or **re-hospitalization** events as possible.

However, there is no gold standard for the intermediate patient outcome proxies, particularly with respect to evaluating the coordination service. Generally, in medicine there is no common understanding about the measurement, evaluation, and improvement of patient health in detail (Mant, 2001). There are several instruments such as scales or evaluation methods that generate indicators for patient health, which are often not described thoroughly or whose quality is questionable (Reiter et al., 2008). To evaluate the outcome of stroke treatment in a long-term perspective, often used acute stroke scales such as the National Institute of Health Stroke Scale (NIHSS) (Williams et al., 2000), the European Stroke Scale (ESS) (Hantson et al., 1994), or the Glasgow Coma Scale (GCS) (Teasdale and Jennett, 1974) are not of interest. They measure neurological deficits, which is of particular interest during the acute treatment. The evaluation of stroke patient health from a long-term perspective is usually done by investigating the **activities of daily living (ADL)**, the remaining **function abilities**, and the **health-related quality of life (HRQOL)** (Johnston et al., 2002). Particularly, for stroke the importance of non-motor skills on the HRQOL has been shown by Haacke et al. (2006), which makes it important to measure HRQOL next to more medical indicators, i.e. ADL and functional abilities. Figure 4.4 shows the most common instruments for measuring the three intermediate patient health proxies.

For measuring **activities of daily living (ADL)**, instruments are used to differentiate between different degrees of disability and dependency in everyday life (Johnston et al., 2002). Usually, questionnaires or interviews are used for assessment. The following instruments are often cited when evaluating ADLs:

- The **Barthel-Index (BI)** is a disease-independent questionnaire which allows to assess the independence of a person regarding activities of daily living and mobility. The questionnaire consists of ten items, which are summed up to a BI score that ranges from 0 points (completely depended on nursing care) to 100 points (completely independent). The score can be determined by a face-to-

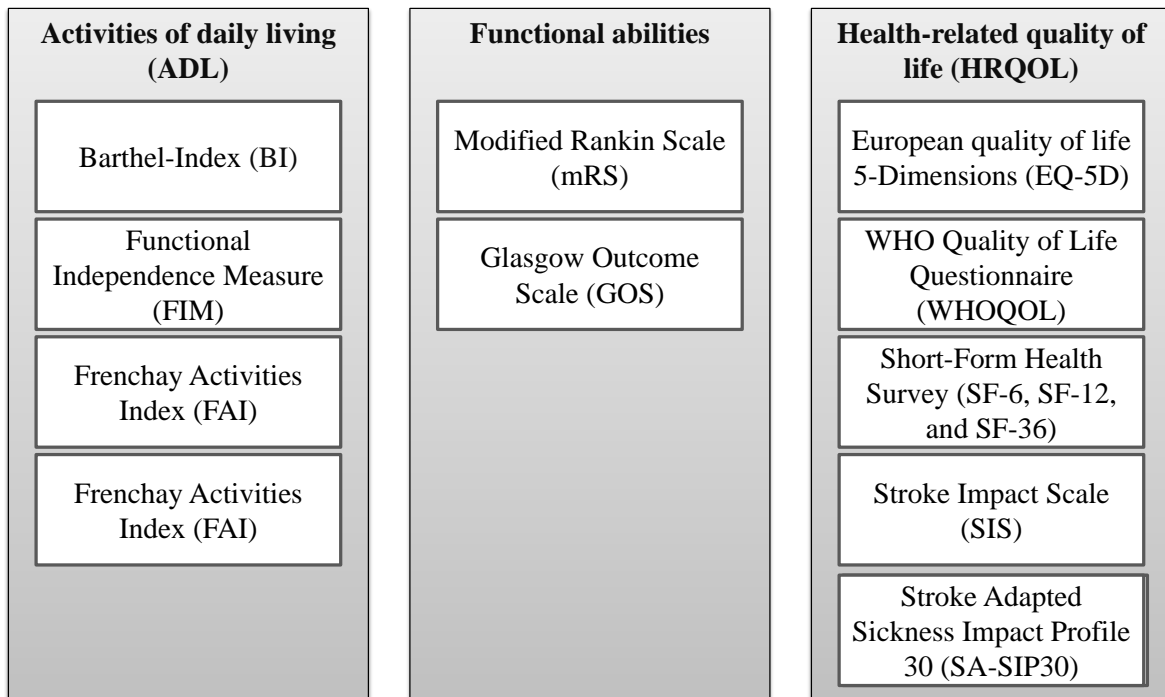


Figure 4.4: Potential instruments for the intermediate patient health proxies (IO).

face or a telephone interview, via observation, and using a survey (Gompertz et al., 1994; Heuschmann et al., 2005).

- The **Functional Independence Measure (FIM)** is an instrument similar to the BI (Laughlin et al., 1995). It was developed to address issues of sensitivity and comprehensiveness of the BI. In addition, it does not only measure physical activities of daily living but also cognitive functions like communication and social interaction (Kwon et al., 2004).
- The **Frenchay Activities Index (FAI)** is a stroke-specific instrument to assess the ADL (Schuling et al., 1993). The FAI consists of 15 items that assess a broad range of activities associated with everyday life. It is a specific rehabilitation test that requires some decision making and demonstration of organizational capability on patient side.

Apart from activities of daily living, another frequently used medical determinant for patient health is **functional abilities**. Particularly, for stroke patients, which often have cognitive impairments, an instrument for evaluating patient health is advantageous that uniquely assesses abilities based on mental disabilities. Mental disabilities are often the cause of prevailing physical disability. The following two instruments are mostly used for stroke (Johnston et al., 2002):

- The **modified Rankin Scale (mRS)** is a widely used instrument that measures levels of handicap (Van Swieten et al., 1988). It is employed to quantify the

functional deficits of stroke patients in seven stages. Therefore, it defines six stages of disability ranging from 0 (no symptom) to 5 (severe disability and receiving constant nursing care), and one additional stage for death (Kwon et al., 2004). In contrast to the BI or FIM, the mRS assesses the functional deficits regarding stroke instead of more general activities of daily living.

- The **Glasgow Outcome Scale (GOS)** is an instrument that is used for patients with brain damage. It provides five outcome categories that describes level of functional ability from 1 (death) to 5 (light damage to the brain causing small neurological deficits) (Jennett and Bond, 1975).

Even though, **health-related quality of life (HRQOL)** is one of the least agreed-upon determinants of the three intermediate patient health indicators, it is acknowledged as one of the most important indicators for intermediate patient health, particularly for patients suffering from chronic diseases (World Health Organization, 2005). It has been argued several times that physical measures such as ADLs or functional abilities do not capture all the facets of patient health (Bodenheimer, 2008; EuroQol Group, 1990; WhoqolGroup, 1998; Luo et al., 2012). For example, depression or social influences can have a major impact on patient health, particularly for patients suffering from a stroke (Jones et al., 2009). Therefore, most prominent concepts for measuring **health-related quality of life (HRQOL)** are presented here:

- The **European quality of life 5-Dimensions (EQ-5D)** is a well-known generic instrument measuring health-related quality of life (EuroQol Group, 1990). This questionnaire consists of two elements: the EQ-5D index scale including the five dimensions (mobility, selfcare, daily activities, pain/discomfort and anxiety/depression) and the visual analogue scale (VAS). Each dimension can be rated at three degrees of severity: no problems, some problems and major problems. Due to the different combinations of answers, they form a set of 243 health states ranging from "33333" to "11111" (Brooks, 1996). Additionally, the VAS is used as a control scale that captures the current feelings of the patient in a scale from 0 to 100. The health states can be transformed to a health utility value depending on the underlying population (Greiner et al., 2005). Two health utility values at different points in time can then be used to compute quality adjusted life years (QALY), which are applicable in cost-utility-analysis. Furthermore, the EQ-5D features a visual analogue scale (VAS) that shows the interval from 0 to 100. The respondents are supposed to mark their current health-related state on this scale. The VAS provides a simple means for acquiring the HRQOL. Since this self-reported value highly depends on the respondent's mood, it is often only used to compare to the more reliable utility value that can be transformed from the five individual dimensions asked by the EQ-5D.

- The **WHO Quality of Life Questionnaire (WHOQOL)** is similar to the EQ-5D and assesses the HRQOL using a questionnaire. The instrument was developed by the WHO-WOL group with different international health centers to design a quality of life assessment that would be applicable cross-cultural (WhoqolGroup, 1998). Similarly to the EQ-5D it assess physical and emotional states of the patients. Additionally it also assesses the individual's perceptions in the context of their culture and value systems, and their personal goals, standards and concerns.
- The **Short-Form Health Survey (SF-6, SF-12, and SF-36)** is a generic instrument to measure the HRQOL (Ware Jr. and Sherbourne, 1992). It comprises eight categories: physical functioning, vitality, bodily pain, general health perceptions, physical role functioning, emotional role functioning, social role functioning, and mental health. The health survey has several variations, for example 36, 12, or 6 questions, and is one of the most frequently used questionnaires to assess HRQOL (Luo et al., 2012).
- The **Stroke Impact Scale (SIS)** is questionnaire for stroke patients that tries to measure HRQOL in eight dimensions using 64 predefined questions (Duncan et al., 1999). The dimensions are strength, memory and thinking, hand function, ADL, mobility, communication, emotion, and participation. As with all instruments that try to measure HRQOL, the SIS explicitly integrated dimensions like participation or thinking.
- **Stroke Adapted Sickness Impact Profile 30 (SA-SIP30)** also is a stroke-specific questionnaire for measuring HRQOL. The SA-SIP30 is a 30-question instrument with eight subgroups (Van Straten et al., 1997).

Since there are no commonly accepted instruments or methods of measurement to generate indicators for patient health (Mant, 2001; Reiter et al., 2008), possible indicators that might serve as performance standards for the coordination service, had to be classified regarding their applicability. According to Donabedian (1988) and Heuschmann et al. (2010) medical indicators have to satisfy the following conditions: **Measurability**, **Feasibility**, **Reliability**, and **Validity**. First, measurability signifies that the indicator has to be a performance standard for patient health. Second, the indicator has to be feasible, which means that data is either already available or can be collected with acceptable effort. Third, the indicator has to be reliable, which means that values can be reproduced by different observers (inter-observer reliability) and that values are consistent (intra-observer reliability). Fourth, a used indicator is valid if, and only if, measured values are related to what they are intended to measure. Based on literature, the identified indicators were assessed regarding the four conditions. Results of the assessment are shown in Table 4.5.

	Instrument	Measurability	Feasibility	Reliability	Validity
Activities of daily living	BI	yes	yes	yes	yes
	FIM	no	yes	yes	yes
	FAI	yes	no	yes	yes
Functional abilities	mRS	yes	yes	yes	yes
	GOS	yes	no	yes	yes
health related quality of life	EQ-5D	yes	yes	yes	yes
	WHOQOL	yes	yes	yes	yes
	SF-x	yes	yes	yes	yes
	SIS	yes	no	-	-
	SA-SIP30	yes	no	-	-

Table 4.5: Evaluation of available instruments for intermediate patient health proxies (IO).

For the activities of daily living, the BI fits best of the three investigated instruments because it is an often used and reliable instrument. The FIM is too complex to be used in the intended outpatient setting and assesses several unnecessary indicators. The FAI, even though specifically designed for stroke patients, is too focused on the medical, rehabilitation setting. It therefore, does not measure what the coordination service intends to improve, the activities of daily living. For the functional abilities, the mRS is the instrument of choice because the GOS needs experts to assess it correctly. Furthermore, the GOS is an old instrument that is not much in use. To measure HRQOL the EQ-5D, the WHOQOL and the SF-x suffice the desired conditions. The stroke-specific instruments have not been used except for pilot studies and, thus, their reliability and validity cannot be established.

In Section 5.3, which introduces the methodology of the study, the instrument usage is described in more detail. For example, the instruments for measuring the HRQOL are investigated in more detail. Consequently, the EQ-5D emerges as more suitable for the study because it allows health economic analysis due to its index-based transforming of the HRQOL value. The EQ-5D is an index based instrument that states HRQOL as an index number. In contrast, the SF-x and the WHOQOL are profile-building instruments that do not aggregate different dimensions of the HRQOL that they measure. Furthermore, the WHOQOL is difficult to apply in other languages and difficult to evaluate (WhoqolGroup, 1998).

4.2 Coordination Service Concept

This section deals with stage three and four of the service design phase: Generating and validating the coordination service concept and its detailed characteristics. The section documents how requirements and key customer needs, which have been compiled in the first two service design phases as described in Section 4.1, have been converted into different service processes and functions. Following the combined software and service engineering approach (see Figure 4.1 in the beginning of this chapter), the coordination service's concepts were designed, evaluated and redesigned in iterative cycles. After identifying key functions, alternate design concepts have been designed and evaluated using four independent workshops with key customer groups, a survey, and patient interviews. Since there are many different stakeholders in the HSN, possible process and workflow concepts for the stroke manager service were only investigated in detail for the personas from Section 4.1

The following subsections report the iterative development of the stroke manager functions in terms of processes and structure, thereby contributing to the second part of Research Question 2. This part deals with the key functions of an independent coordination service along the complete patient care pathway. Overall four workshops with the key customers *patients and relatives, medical staff, social services, and hospital administration, and outpatient healthcare service providers* were carried out. Additionally, data was used from a survey among hospitals about the contemporary discharge management and continuous interviews with patients during a first four week phase.

In the first subsection, the development of the workflow processes and the key functions are introduced. It presents the findings of the first two workshops, in which the conceived workflow and stroke manager service concepts were discussed with domain experts, as well as the results of the survey. Particularly, the workshops investigated the specific information that need to be exchanged from a patient-centered perspective as well as from a provider perspective. In the second subsection, the final workflow processes of the stroke-specific coordination service are described in detail. The third and fourth subsection deal with the integral parts of the ICT-structure. The former presents the findings of two more workshops with domain experts, in which the developed ICT-structure and its fit to the conceived workflow was discussed, as well as the results of the continuous interviews that were administered during the test phase of devised ICT. The later presents the developed ICT-structure that is used for the stroke-specific coordination service in detail.

4.2.1 Service Process Development

The "ideal" stroke care pathway was introduced in Section 3.3.4. It can be divided into three major phases: Acute inpatient treatment, post-acute inpatient treatment, and post-acute outpatient treatment (See Figure 3.3). Since the developed coordination service focuses on post-acute treatment, the two post-acute treatments are relevant. Additionally, the transition between post-acute inpatient treatment and post-acute outpatient treatment is investigated in more detail because traditionally the most constrictions to information flow occur during transition (Bodenheimer, 2008). Therefore, inpatient phase, transition phase, and outpatient phase were considered for development of the coordination service processes. They are illustrated in Figure 4.5.

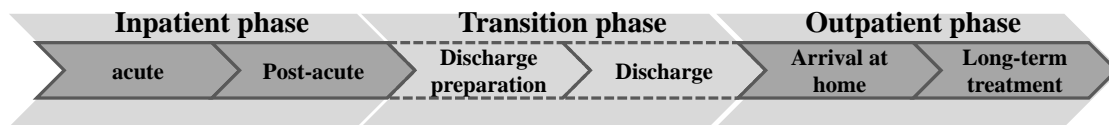


Figure 4.5: Phases of the patient care pathway process, which are considered for the coordination service concepts.

The first phase, inpatient treatment, consists of acute and post-acute treatment phase. In the acute phase, patients are rather passive and only hospital *medical staff* is active. In the following post-acute inpatient treatment phase, patients and relatives as well as stakeholder groups from the hospital might benefit from the stroke manager service. Especially, the patients and relatives suffer from high information deficits regarding the disease and common treatment practices. Here, the stroke manager service can provide valuable individualized information for patients. Moreover, since acute and post-acute treatment are generally performed by different *medical staff*, information generated in acute phase, like treatment advice, is sometimes not conveyed to the stakeholders in the post-acute phase. These information barriers between acute and post-acute phase can be overcome by a coordination service like the stroke manager.

Since stroke patients usually need long-term outpatient treatment and there are reportedly the most information flow constrictions between inpatient and outpatient treatment stakeholders (Bodenheimer, 2008), the transition phase from inpatient to outpatient treatment is of high importance. It is divided into a discharge preparation and actual discharge phase. Here, all of the identified stakeholders – *patients and relatives, medical staff, administration staff, social service staff, and outpatient healthcare service providers* – have to be considered. All benefit from a coordination service that serves as a central information hub and provides individual information when they are needed. However, the focus is put on inpatient stakeholders because they mostly provide the relevant information that healthcare service providers in

Stakeholder	Process level	Structure level
medical staff	relief of "overhead" work	access to all patient information
social services	support in information gathering and distribution	access to all patient information
hospital administration	support in patient tracking	-
outpatient healthcare service providers	support for communicating with medical staff	access to all patient information

Table 4.6: Results of the first workshop: stakeholders' desired functions of the stroke-specific coordination service.

the succeeding phases need. The last process phase is the outpatient treatment that is split into the first days at home, i.e. the beginning of the outpatient treatment, and regular, long-term outpatient treatment. During this phase, the stroke manager can still serve as information hub providing outpatient healthcare service providers with necessary information while supporting the patients individually.

Building on the previously identified coordination service requirements and the service performance standards, detailed workflow concepts for a stroke-specific coordination service were developed for each of the three phases. The workflow concepts for the coordination service were developed in order to alter the current process in a healthcare service network to improve the healthcare service quality. They have been discussed in two workshops with the involved stakeholders and, subsequently, have been refined. Additionally, a survey has been administered and continuous interviews with a typical stroke patient and the care-giving relative were conducted.

Goal of the first workshop was to gather specific information needed by involved stakeholders and to refine the workflow concepts that have been initially created. Participants of this workshop were one physician, two nurses, two social workers, two hospital administrative staff members, and two members of a facility that provides outpatient healthcare services. In this workshop, the possible stroke manager service concepts have been discussed from both perspectives, the healthcare service provider perspective and the healthcare service consumer perspective, i.e. patient perspective. Apart from discussing the detailed workflow of the stroke-specific coordination service, the workshop yielded stakeholder's desired key functions of the service (see Table 4.6). During the workshop, the key functions were separated into the two levels of healthcare delivery (see Section 2.1.2 for details): process and structure. Whereas the desired key functions on the process level were different, the stakeholders agreed on the structural level. They want an ICT that allows them to access the patient information easily.

In addition to the workshop, quantitative data from a survey among hospitals has been evaluated with respect to inpatient treatment. The survey's findings regarding feasibility and usability of discharge support software are reported by Schmon and Biena (2013). The survey was sent out to people responsible for discharge management in all German hospitals such as *medical staff*, *social services* and *hospital administration*. Apart from software-specific findings, results show that organizing the transition phase between inpatient and outpatient treatment in Germany is often not supported. Only less than 20% of the respondents contact general practitioners, outpatient social services or other outpatient healthcare service providers once a week or more often. Furthermore, only 69% of the respondents have standardized data acquisition even though knowing what kind of patient data is acquired is beneficial for all involved stakeholders.

Based on the first workshop and the survey, the coordination service's workflow was analyzed from a healthcare provider perspective. In order to focus on the patient perspective, a second workshop was carried out with two stroke patients, two care-giving relatives, and three members of hospital discharge office. Physicians and administrative staff were excluded from this workshop because they are not as strongly involved in discharge processes as patients, relatives, and hospital staff taking care of discharge. As stated by Langhorne et al. (2011), individual information for stroke patients are important, and doctors are the most important source for these information. Among others, improving patient self-management competencies has been identified as performance standard for the coordination service (see Section 4.1). It is acknowledged to be very important and can best be achieved by "patient empowerment" (Bodenheimer et al., 2002). Thus, providing patients with information is an essential function of the coordination service concept. Since the target group of stroke patients and their relatives is very heterogeneous, needed information is very individual. During the second workshop, the individual and necessary information have been characterized and clustered in seven topics:

1. Introduction that contains information about all the available information and stroke in general.
2. Personal information containing specific, individualized information, such as a list of healthcare service providers close to the patient's home or the personal medication history.
3. Information about inpatient processes and possible treatments.
4. Information about the discharge processes.
5. Information about the outpatient processes and available healthcare services.

6. Information about the general care of stroke patients, particularly in outpatient settings.
7. Appendix that contains a glossary, further literature, websites that provide information about stroke, and contact details of stroke organizations, such as the German stroke foundations, local self support groups, and other organizations that might be helpful.

After collecting and clustering the information, they have been prepared and bundled in a folder as illustrated in Figure 4.6. This stroke-specific folder, which is called paper-based stroke health book (SHB), was developed as additional component of the stroke-specific coordination service that can be issued to all stroke patients during the coordination process. It consists of a basis amount of information from the all the seven topics that have been identified in the workshop. The paper-based SHB offers the possibility of adding additional, individual information according to the individual stroke patient's situation during the course of the disease. Its purpose is to relieve stroke patients from time-consuming and often futile search for relevant information. To validate and potentially refine the information provision function as part of the stroke-specific coordination service, a four weeks test phase with a typical stroke patient and the corresponding care-giving relative has been administered. During this phase, continuous unstructured interviews were administered to acquire feedback. Overall, the information clustering and transformation to the SHB have been proven to be useful in the field. Only minor changes regarding layout or text passages were made.



Figure 4.6: Picture of the paper-based stroke health book (SHB).

Based on the previously identified service's requirements and performance standards, essential functions as well as thereby arising workflows of the coordination service have been deducted. Workflow and functions have then been validated and refined in based on two workshops, one survey, and continuous interviews with a typical stroke patient. In subsections 4.2.2, 4.2.3, and 4.2.4, the process and the according ICT-structure are presented in detail. Main purpose of the service should be to support the transition phase (see Figure 4.5) to improve the coordination in the healthcare service network. However, specific configurations of the stroke manager service functions in the workflow are debatable. Depending on the situation, it might be sensible to implement different versions of the following functions.

The stroke manager role: The process requirements P1 and P2, which state that the stroke manager service has to affect the complete patient care pathway and has to be person-oriented service, respectively, demand a central service involving a person: the stroke manager. The stroke manager does not necessarily have to be a real person. Yet, due to the individual situation that is difficult to be captured by an automated decision support system and the patients emotional state, a real person is favored by the patients. Furthermore, if a real person is involved, patient consent (process requirement P6) is easier to accomplish.

Location of the stroke manager service: From healthcare service provider's perspective, it is debatable, where the stroke manager service should be hosted. To provide enough benefits for stakeholders in the HSN that initially hosts the stroke manager, it has to be a rather large stakeholder. Moreover, due to legal requirements, particularly L1 and L3, least additional effort is produced by hosting the stroke manager service in a hospital that treats stroke patients on a regular basis. A hospital-based stroke manager also facilitates process requirement P6. Therefore, all the workshop participants agreed that the most benefits are created if such a service is hosted in a hospital.

Duration of the active patient support: When talking about a coordination service along the complete patient care pathway (process requirement P1), inpatient and outpatient settings have to be considered. Domain experts in the workshops agreed with current literature stating that the most effects are generated in the first 3 months after a stroke occurred. Additionally, support for up to 12 months after the stroke and home visits (process requirement P3) in the outpatient phase are beneficial.

Individual patient information: The individual patient information is an essential function to achieve patient empowerment and, thus, an improved healthcare service quality. Nevertheless, the style and quantity of the individual information may vary according to the situation. The conceived SHB has been

proven to be useful in practice but its configuration is not fixed. Yet, either configuration has to incentivize the patients and the involved healthcare service providers to share the information (process requirement P4) while satisfying legal constraints. Even though legal requirements L1, L2, and L3, which target documentation of patient data, are originally geared towards ICT, they also apply to paper-based records.

ICT usage by healthcare service providers: In the requirements and during the workshop the ICT support of healthcare service providers has played a large role. On the one hand, it allows efficient information flow between involved stakeholders, which is expressed by process requirement P5. In order to address structure requirements S2, S3, and S5, standardized electronic health records (EHRs) are favored that are accessible by all involved healthcare service providers and patients. On the other hand, there are large costs related to implementing, introducing, and maintaining such an EHR and several unresolved legal issues (see requirements S6, and L1 to L5). If many governments do not succeed in implementing a comprehensive EHR, it is not a feasible option for a coordination service such as the stroke manager service. Since most of the healthcare service providers already have some sort of ICT in place to store patient data, the stroke manager service only incorporates a workflow management software for the stroke manager. Therefore, instead of creating a novel software, existing software is used and incorporated in the stroke manager processes (see requirements S1-S3).

ICT usage by patients: Similar to the ICT usage of the healthcare service, there are advantages and disadvantages of providing ICT for patients and relatives. They have to provide hardware security measures (structure requirement S6) and abide by the legal regulations (see legal requirements L1-L5) while providing advantages that are explicitly required (see process requirements P4 and P5). Especially, telemedicine devices, such as automated blood pressure measuring devices, have been proven to support patients suffering from a chronic disease. Due to their high age, it also seems sensible to introduce ICT support to allow the patients to live as long as possible in their homes. However, it is not known if the particular group of stroke patients is capable of and willing to use these devices, which is essential as stated in process requirement P6.

This subsection established the major functions which the coordination service should incorporate regardless of their configuration. The coordination service needs to have a central entity, which is called stroke manager, that provides individual information for the involved stakeholders. Since a patient-centered perspective is pursued, the stroke manager especially needs to provide individual support for patients and their care-giving relatives. This patient-centered support needs to take place for

several months after patients get discharged from hospital to ensure a gradual transition. Moreover, ICT-support for the involved stakeholders is an essential function the coordination service has to provide. Otherwise, a central coordination service as conceived during the development cannot provide the information efficiently. Building on these functions, in the following subsection, the stroke-specific coordination service workflow process is described.

4.2.2 Coordination Service Processes

This subsection presents the processes of the final stroke-specific coordination service. For a graphical illustration of the collaborative processes between the stakeholders the Business Process Modeling Notation (BPMN) is used. It has become the de facto standard in academic and practice communities for business process modeling (Recker, 2010). For each task the involved stakeholders, their respective role and the exchanged information are illustrated. The stroke-specific coordination service encompasses the complete post-acute stroke management beginning in the hospital that performs the patient's acute treatment and ending in the outpatient phase when a stable service network has been established. Thus, the workflow process descriptions are divided according to the three patient care pathway phases that are illustrated in Figure 4.5: Inpatient treatment, discharge, and outpatient treatment.

Phase 1 - Inpatient Phase: After successful acute treatment of the stroke patient, the coordination service starts in inpatient setting. If the patient continues to be treated in the hospital and gives consent to being supported by a stroke manager, the coordination service is offered. This first phase during the acute treatment is illustrated in Figure 4.7. The coordination service is started during the first four days of acute treatment by physicians from the stroke unit contacting informing the stroke manager about eligible stroke patients via email, phone, face-to-face appointments, or the hospital information system.

After being triggered by physicians, the stroke manager looks up the patient's data in the hospital information system. The stroke manager then approaches patient and care-giving relative – in case the latter is available – to gather further information, particularly about the patient's environment. At the same time, the stroke manager already supplies individual information about the next steps of the treatment process to patient and care givers, which are usually close family members. After the initial meeting, the stroke manager conveys relevant information to the utilized customer relationship management tool (CRM tool) that the stroke manager uses as ICT-support. As soon as the patient is stabilized and reliable predictions about the future prospects are made by the physician, the patient profile in the CRM is updated and patients as

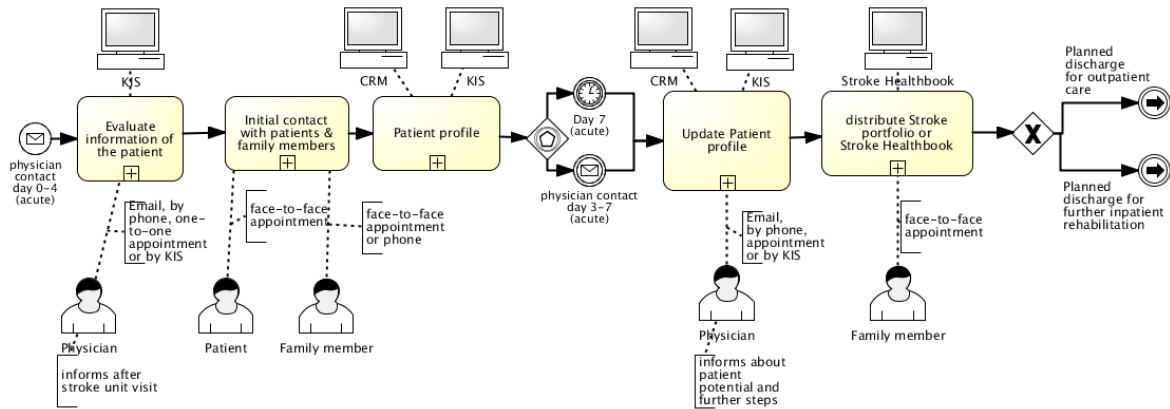


Figure 4.7: Workflow during inpatient treatment.

well as family members are informed about the next steps. At this point, patients and family members are also given the paper-based stroke health book (SHB) and, if wished-for, the electronic stroke health book (SHB). Both SHBs comprise individual information for patients and care-giving relatives. After supporting the first phase of inpatient treatment, the stroke manager continues to support the discharge preparation.

Phase 2 - Discharge Phase: Figure 4.8 visualizes the stroke manager's workflow during the discharge phase. It has two starting points depending on patients' next steps, either being discharged right away or staying in hospital after the acute inpatient phase. The workflow of being discharged right away is illustrated on top. It shows the stroke manager's workflow when patients leave inpatient treatment and pass over to outpatient treatment. The figure's lower part illustrates the stroke manager's support during a continued inpatient treatment, in which the discharge can be prepared more ahead-of-schedule.

During the discharge process, the stroke manager supports and coordinates the discharge by communicating with hospital staff such as nurses, physicians, or social service offices about the patient status via email, phone, face-to-face appointments, or the hospital information system. At this point in time, the stroke manager also communicates with regional service providers that will perform subsequent outpatient treatment as well as patient and care giver. If the patient is not discharged right away, the stroke manager supports the involved stakeholders during inpatient rehabilitation and supports discharge preparations. Here, the patient and the care giver are also kept up to date concerning the next steps in the treatment process and individualized information are distributed to them. Additionally, the hospital staff is supported by making sure that up to date information about the patient are always available. Depending on the length of inpatient rehabilitation this "discharge preparation"

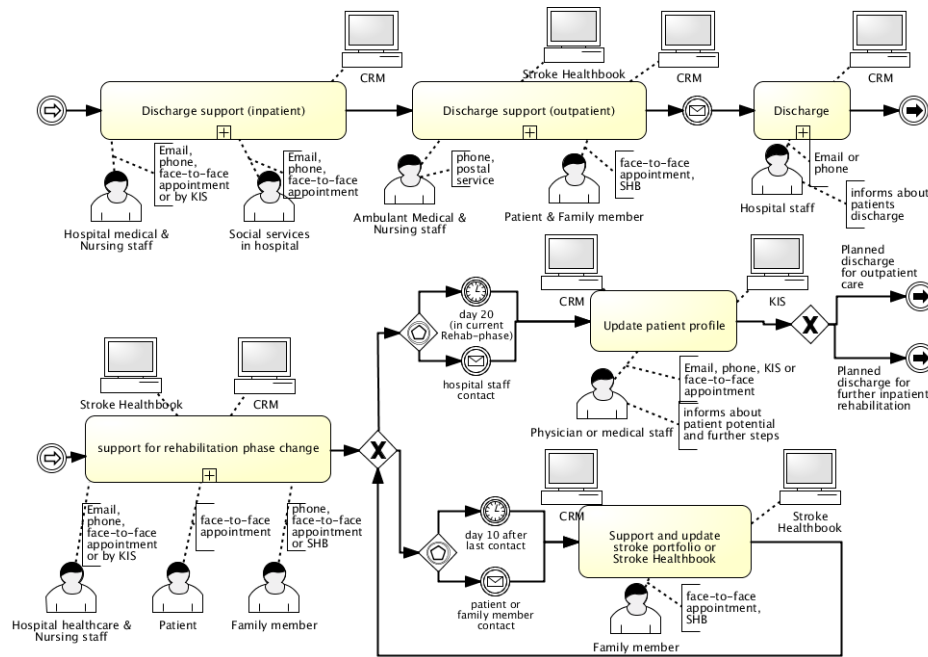


Figure 4.8: Workflow during discharge preparation.

of the discharge phase lasts several weeks up to months before the patient is discharged from inpatient treatment.

Phase 3 - Outpatient Phase: The third phase of the stroke manager service is the outpatient treatment and its workflow is illustrated in Figure 4.9. Seven days after the patient has been discharged from the hospital or earlier, if the stroke manager is requested, patients and family members are contacted and visited in their home environment. After that, the outpatient phase includes several parallel activities. Depending on the state of the patient, there are more visits and support necessary or the stroke manager service is put on hold if the patient is successfully embedded in the regional network and does not require further support. Either way, three months and twelve months after their stroke incident, patients are interviewed to record their status. Subsequent to all interactions between stroke manager and patient, family member, or any outpatient healthcare service provider, the individual information in the electronic SHB and the stroke manager's CRM is updated. At the end of the stroke manager support, which is twelve months after the patients' stroke incident if they have not opted out before, there is a final appointment at the patients' home to collect the electronic SHB and possibly missing data.

4.2.3 ICT-Structure Development

After the workflow process of the stroke-specific coordination service has been established, service details have been elaborated, particularly regarding the used ICT.

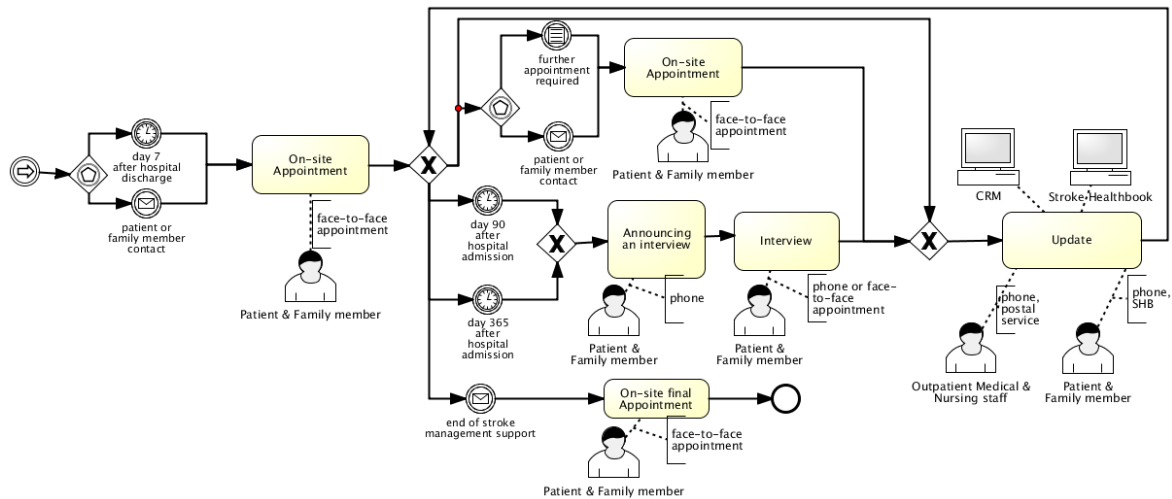


Figure 4.9: Workflow during outpatient treatment.

The development is in line with the findings of Page (2003), which conclude that instead of using ICT in healthcare to support existing processes, ICT should transform the processes to be more efficient regarding the initial goal. For example, to improve the quality of the physicians' work by providing an electronic health record that allows access to all the patient data, using the electronic health record should not require additional effort. It should rather be a supportive tool and fit or even improve the workflow. In the work at hand, the ICT-structure of the coordination service was developed based on the workflow process concepts described in the previous subsection. During the development, provider perspective and patient perspective were incorporated. For this the personas described in Section 4.1 – *patients and relatives, medical staff, administration staff, social service staff, and outpatient healthcare service providers* – were employed. In both settings, the evolutionary prototyping proposed by Tate (1990) was used and two separate workshops with the future users of the ICT were carried out.

From a provider perspective, the stroke manager is the main stakeholder that serves as a central point of contact. The stroke manager uses a customer relationship management tool (CRM-tool) to handle patient data efficiently. For flexibility, the CRM-tool was implemented as a software-as-a-service module that can easily and securely be accessed with a web browser. It extends common CRM-features like maintaining contact information and associations, mail integration, calendar synchronization and follow-up tracking for the healthcare domain. The software provides a basic patient health record (PHR) that can be accessed by patients, their care-giving relatives and other healthcare service providers. Furthermore, the CRM-tool has been adapted to act as workflow management software for the stroke manager. It incorporates automated patient assessment forms and reminders that guide the stroke manager through the process of supporting patients and care-giving rel-

atives. The CRM-tool for the stroke manager has been developed using the evolutionary prototyping involving single users regularly during the development phase.

After a first prototypical implementation a workshop with one physician, two social workers, and three nurses was carried out. All of the participants have the capability to take the role of a stroke manager. Thus, their participation in the workshop provided valuable feedback to the distinct functions of the CRM-tool and its integration into the developed workflow of the coordination service, which has been presented in Section 4.2.2. Overall, the feedback was positive and only minor changes – particularly regarding terminology used in the CRM-tool – had to be realized afterwards.

From the patient perspective, the paper-based stroke health book (SHB) has been developed as a means to provide individual information for the patients. It has been adapted to the cognitive capabilities and motor skills of the common stroke patient, which were described in Section 4.1. To facilitate advantages of ICT, i.e. improved documentation and data exchange, in this setting, an electronic SHB has been developed, which is connected to the CRM-tool used by the stroke manager. It was intended to be used in addition to the paper-based SHB, and to be provided optionally to patients and their relatives starting in acute phase. The SHB allows the stroke manager to actively monitor patients and communicate via unlocking certain information texts, scheduling appointments, or sending reminders of tasks. In addition to providing means for the stroke manager to influence and record patients' adherence more directly, it also allows to integrate telemedicine devices, e.g. blood pressure devices. The electronic SHB's typical usage is captured in a picture in Figure 4.10.



Figure 4.10: A stroke patient using the electronic stroke health book (SHB)

The ICT-structure on patient side, the electronic SHB, was also developed using the evolutionary prototyping approach including patients' feedback during the development phase. To achieve the SHB's intended goal of improving individual support, compliance, and secondary prevention, its functions need to be expedient. Therefore, it was validated in a workshop with four patients and four care-giving relatives. They were given a questionnaire after the workshop. The questionnaire asked the participants to rate the electronic SHB with school grades (1 equals very good and 5 equals failed). Results are shown in Figure 4.11. Overall rating of the electronic SHB was very positive, which is in line with most positive ratings of single items, e.g. information aspects or colors. Particularly, information available on the electronic SHB was rated high. Usability, colors, and information appearance of the SHB were also given high grades. Only the usage of the blood pressure device was criticized and the fonts were too small. Both issues were resolved subsequently.

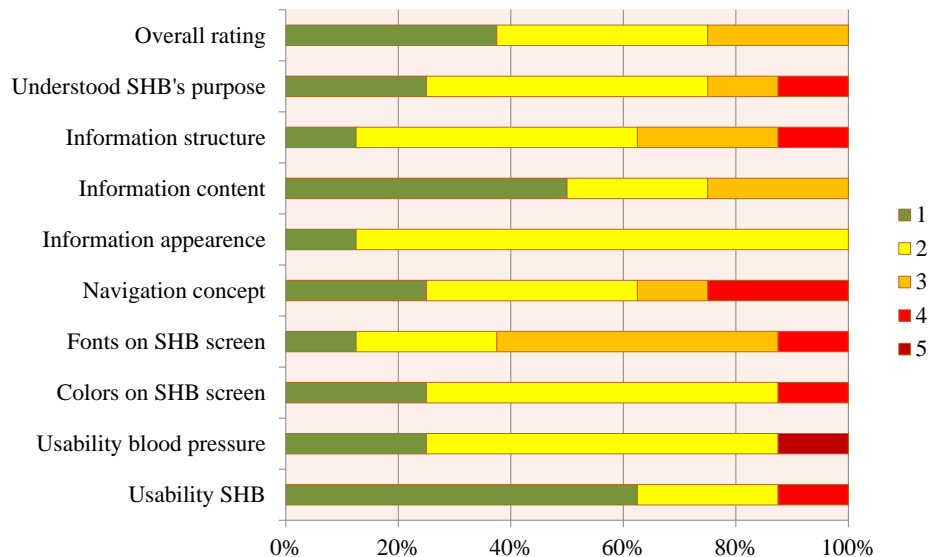


Figure 4.11: Results of the fourth workshop: User rating of the electronic stroke health book (SHB) in school grades (1 = very good, 5 = failed).

As the previous subsections did for the workflow processes, this subsection presented the development of the ICT-structure for the coordination service. In doing so, the major functions of the ICT-structure that the coordination service uses were established. Building on these findings, in the following subsection, the complete, stroke-specific coordination service ICT-structure is described.

4.2.4 Coordination Service ICT-Structure

The coordination service's ICT-structure that was developed is depicted in Figure 4.12. Major parts as well as their necessity according to the requirements will be

described in the next paragraphs. The stroke manager is supported by a customer relationship management (CRM) software and two electronic patient records: A patient medical record (PMR) and a patient health record (PHR) that are mainly used by medical service providers and patients as well as relatives, respectively. There are different approaches to electronic health records' concepts depending on the users' requirements. Because of motivational and legal issues (see requirements S3, S6, L1, L2 and L3), the ICT-structure incorporates the two essentially different approaches. One is patient-centered and majorly supports patients. The other one is case-oriented aiming at allowing different medical service providers (e.g., hospital staff and ambulatory clinic physicians) access to necessary data they need to treat patients the best way. The two electronic patient records are regarded separately because if, for example, a patient refuses to share important information of a personally controlled health record to the physician, the idea of an electronic health record is undermined. Then, even though the stroke manager has access to patient data and could provide it to other stakeholders, the coordination cannot take place because it is prohibited by law. This might be the case if the patients cannot judge correctly what information is important or if they simply refuse to share the data because of personal issues. Additionally, the stroke manager makes use of the electronic SHB that is distributed to the patients and their care-giving relatives. If the electronic SHB is used, it allows both remote integration of assisting technologies (e.g. telemedicine devices) and an individual, patient-centered access to the patient health record.

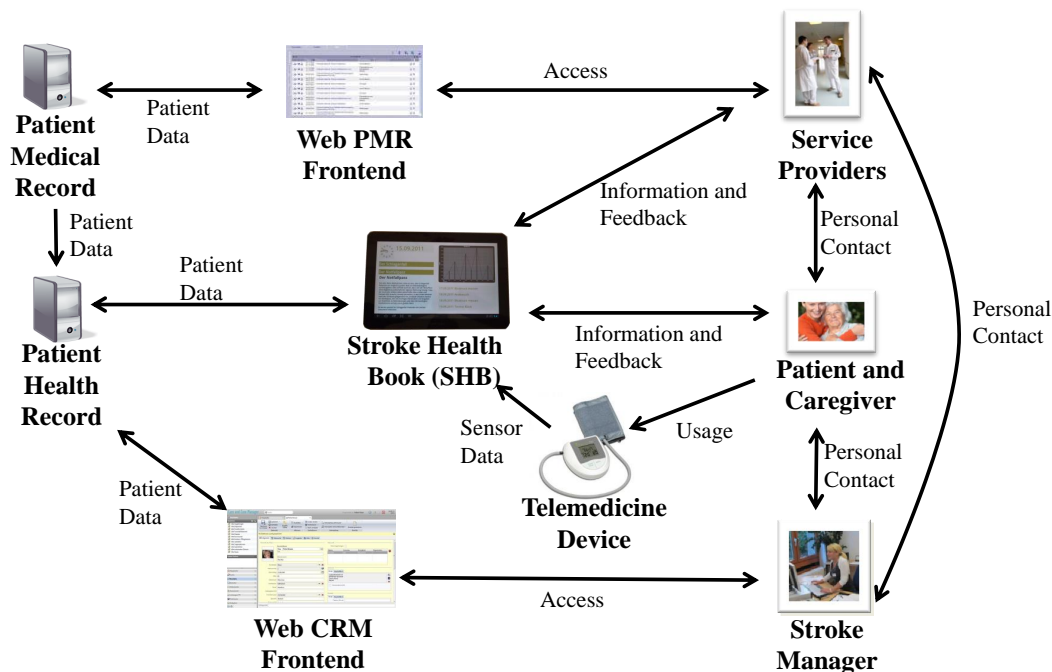


Figure 4.12: Envisioned post-acute stroke manager ICT-structure.

Patient Health Record (PHR)

An electronic patient health record (PHR), albeit coordinated by the stroke manager, is integrated in the ICT-structure, more precisely in the CRM. It enables the stroke manager to provide individualized information to patients corresponding to their current state. The stroke PHR can store individual and stroke-relevant data that is assessed by the stroke manager. Furthermore, data from telemedicine devices, assisting technologies, or the patient – e.g., blood pressure, activity and medication or therapy compliance – can be stored in the PHR. According to requirements P4 and S5 the interdependency between individualized information for patient and care giver because of the data they are providing is an important part of the PHR. In the process of designing the stroke manager ICT-structure, existing health records were examined. Based on the work of Sunyaev et al. (2010) and additional research, possible EHR were identified and evaluated. The two major requirements were open source and easy adaptability. However, no available product provided these characteristics at the time of screening. There are numerous EHRs of different dimension, but most of them are neither open source nor did any of them support the idea of storing individualized information adapted to the progress of the disease as well as patient-relevant data.

Consequently, a unique stroke health record was developed, which adopts most of traditional PHR characteristics, but also implements additional data structures for individualized information, checklists and personal schedules. During the workshops, the latter two were identified as very important by the respondents, but missing in current personalized electronic health records. In Figure 4.13 the underlying structure is illustrated in a diagram based on the Unified Modelling Language (UML). It shows the connection between different main data structures of stroke manager, patient, and other involved healthcare providers, i.e. staff, as well as the auxiliary data bases.

Patient Medical Record (PMR)

The electronic patient medical record (PMR) supports communication and data exchange between hospitals and associated medical service providers. In the ICT-structure, according to requirements S2, S2, S6, P1, P3, and L3 a web-based electronic medical record is integrated that allows medical service providers and involved physicians to easily exchange relevant information (e.g., diagnostic images and medical reports). For this exchange it creates a master-patient-index (MPI) that uniquely identifies patients' records regardless of their individual identification in the individual facilities. Yet, the only centrally stored data is the MPI as the documents are referenced at their original site and only made accessible through the Internet. Additionally, this capsuled concept of a distributed EMR that is updated and used by medical service providers allows to independently add new functionalities (e.g., new image viewers, messaging or analysis tools) and participating in-

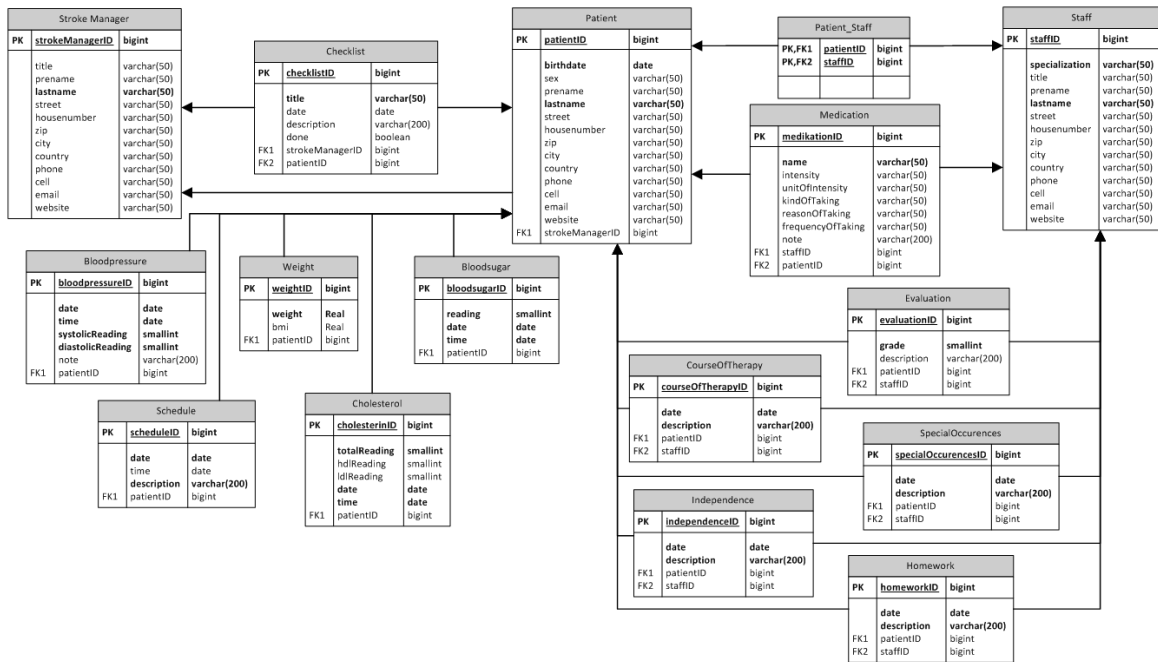


Figure 4.13: UML diagramm of the patient health record (PHR).

stitutions as well as a sophisticated user rights management on a patient case basis. Nevertheless, according to requirement S6 and the legal requirements a patient's agreement is a prerequisite for the possible medical data exchange and referencing of the patients' data in the patient medical record.

Customer Relationship Management (CRM Software)

The main part of the ICT-structure is the customer relationship management (CRM) software that allows the stroke manager to efficiently coordinate and keep track of the patients, relatives and other involved stakeholders. This kind of software permits a process-oriented workflow support of the stroke manager's daily work (see requirement S1, S2, S5, I3, L1 and L2). It connects the two patient records, the stroke health book (SHB), and also the telemedicine device remotely. The chosen CRM software is already used as a CRM software by care and case manager. This facilitated the adaptation to the healthcare domain (e.g., healthcare instead of regular CRM notations were already used in the graphical user interface). It satisfied the requirements for the post-acute stroke manager service through its three main characteristics: Cloud-based (requirement S1), flexible technical base (requirement S2), and automated workflow and documentation support (requirement S3 and L2).

The automated workflow and documentation support is indispensable for the stroke manager to assist in organizing patients, caregivers and other contacts as well as distributing the relevant information in the HSN at the right point of time. For this reason, the CRM offers a clear and systematic documentation. Dossiers for patients, relatives, physicians, therapists and other service provider are filed

and associated with each other. Furthermore, depending on the stroke patients' actual state, necessary tasks are either automatically performed or the stroke manager is prompted and reminded. This includes, for example, performing assessments, information distribution, coordinating the next tasks along the patient's treatment pathway and organizing appointments. The integrated automated reporting function provides additional documentation functionality. Because of its cloud base, it is a distributed system that allows access at any time from everywhere. Other advantages are easy external technical support and maintenance as well as a general data security solution (requirement S6, L1, L2 and L5). Due to the flexible technical base, the CRM connects different technical entities (e.g. SHB and other software as well as hardware).

Electronic Stroke Health Book (SHB)

The electronic, mobile SHB is distributed to patients and care-giving relatives (see Figure 4.14). Goal of the SHB is to actively provide personalized information and support patients as well as caregivers while they in turn provide data about their current status. There is strong evidence that this increases patient satisfaction, mood and compliance while reducing information deficits concerning stroke and organizational knowledge (Smith et al., 2008). Instead of simply granting patients and caregivers access to an electronic PHR or PMR, an SHB was designed that incorporates and enhances the PHR functionalities to meet the identified requirements (S3, S4, S5, S6, L5). Since few people want to store medical data just for the data's sake, the patients have to have an individual benefit. The designed stroke health book has to be accessible from anywhere, provide individualized and relevant information regarding the patient's state and allow connecting additional technologies (e.g. assisting and telemedicine technologies).



Figure 4.14: The electronic stroke health book (SHB).

Individualized and relevant information have to be provided to patient and care-giver. Therefore, the electronic SHB is accessible by both parties. Apart from gen-

eral information about post-stroke management, individual information is also provided depending on the patient's state recorded in the CRM tool by the stroke manager. They are sent via a mobile communication network to the electronic device. Likewise, patient and caregiver are individually informed and supported regarding the next steps in the treatment pathway, such as appointments or administrative tasks. Due to the results of the first set of interviews, which focused on the general information deficits of stroke patients and their caregivers, no online community or social media functions were integrated in the SHB. The results of the interview were reported in Section 4.1.2 and indicated that health 2.0 tools are not feasible for the stroke population of interest. Only the static links to the available online information are included.

Additional telemedicine or assisting technologies (e.g. electronic blood pressure measurement devices, automatic stove control etc.) can be integrated easily because of the stroke health book's mobile character. It can be connected to the CRM software and the underlying electronic PHR. The underlying PHR offers the data structure to store the individual data and its connection to the individual patient data already present in the CRM allows utilizing the additional data provided by the patient to modify the information presented by the SHB. This in turn, is an incentive for the patient to provide current data.

Telemedicine and Assisting Technologies

In addition to the core elements of the coordination service ICT-structure, telemedicine and assisting technologies are integrated. According to requirement S5 other technologies should possibly be integrated into the post-acute stroke manager infrastructure. Following requirement P3, the coordination service ICT-structure exemplarily integrated an electronic blood pressure measuring device. Thus, patients can easily document their blood pressure and doctors can access the data remotely to ask the patient to come to the doctor's office if necessary (see requirement P3). Currently there are few telemedicine devices that are technically sound and whose medical benefit has been proven, which are available for patients to simply buy from the regular market (Paré et al., 2007; Jaana et al., 2009). However, the potential of connecting other telemedicine technologies, e.g. scales, activity sensors etc., is large because of the possible easy collection, transfer, and evaluation of health data that is not yet available (Paré et al., 2007). When looking at the quantified self movement and recent advances in the consumer market of telemedicine devices, in the future, connecting these technologies will be important (Gimpel et al., 2013). Particularly, the upcoming mHealth development that exploits the widespread use of smart phones pushes the everyday use of telemedicine devices that need to be incorporated by the ICT-structure of the coordination service².

²There are several small and medium sized companies that provide ready to use telemedicine devices that can be easily used in everyday life. For example, Beurer, Bodytel, Fitbit, Medisana, Tanita,

4.3 Conclusion & Discussion

This chapter presented results of the stroke-specific coordination service's development. In doing so, Research Question 2 was investigated, which studies the characteristics of an independent service that improves the information flow between the stakeholders of an HSN. Both, coordination service's requirements (RQ 2.1) and key functions (RQ 2.2) were presented. The development was conducted according to the service engineering methodology and service research methodology that have been introduced in Chapter 3. Following the combined service engineering and software engineering approach, the coordination service's key customers, general requirements, and stroke-specific performance standards have been determined. The coordination service's key functions, i.e. the characteristics regarding workflow process and ICT-structure, have been presented.

Summary

In the first two service design phases, the initial requirements and specified performance standards of a coordination service were extracted from analyzing documents such as state-of-the-art literature, guidelines, or internal documentation and from semi-structured interviews. Here, the initial, assumptions having a "patient-centered" focus, being "centrally administered," and involving a "socio-technical system" have been confirmed. Further, additional requirements regarding processes, structure, and legal constraints have been identified. The general requirements Before these theoretical requirements have then been transformed to a feasible coordination service, they were augmented by stroke-specific performance standards that have been distilled employing documentation analysis as well as observation and shadowing sessions.

During the second two service design phases, the coordination service concepts that have been deduced from the requirements were validated regarding their feasibility and structural configuration. In four workshops an artificial test-bed environment was created for patients and healthcare service providers to evaluate the workflow processes and the underlying ICT-structure. First, the workflow processes were developed and validated independent of the ICT-structure. Second, the ICT-structure was developed in order to support the workflow processes optimally.

During the evaluation, it became evident that a web-based CRM solution is most feasible even though the adaptation to the common medical phrasing (e.g. patient instead of client) was more difficult than expected. The major advantage for the hospital staff was the possibility of removing paper-based health records from their

Vitaphone, Withings and many other small companies provide devices that are explicitly developed for consumers. Additionally, large insurance companies, health maintenance companies, and pharma companies are also starting to invest.

daily work routine. Nevertheless, observing the hospital staff using the software prototype made it clear that sophisticated training material and hands-on-sessions have to be provided when implementing the service. Unexpected data security issues were identified, which were not difficult to solve, but took several months to be approved legally. The stroke patients were content and embraced the conceived functions (stroke-related information, measuring blood pressure and managing appointments) readily. They used the ICT surprisingly intuitive and were keen on using the prototype at home. During the complete design phase major technical issues regarding Wifi stability and hardware reliability had to be resolved. Due to the evolutionary prototyping approach, the workflow processes and ICT-structure could be refined in practice. In fact, several discrepancies between the theoretical workflow in the hospital and the actual processes were revealed, which required to adjust the initial workflow processes. Nevertheless, a stroke-specific coordination service was successfully developed that meets the identified requirements (see Table 4.7). Service's workflow processes and underlying ICT-structure have been validated to be appropriate to improve healthcare service quality in complex inter-organizational settings of healthcare service networks.

The stroke-specific coordination service consists of a CRM-tool combined with two electronic health records of which one supports the service provides and the other one empowers the patient. The latter is used in a mobile stroke health book that allows distribution of individualized information at the right time to patients and their care-givers. Through connecting the ICT-structure with the service, it becomes an integral part of the post-acute management process instead of looking at isolated, intra-organizational processes or ICT, how it is generally done in the area of EHR (Häyrinen et al., 2008). Since the patient data is handled from the start using ICT, there are no legacy paper-based records and the traditional paper-based retrospective data collection is discarded. Furthermore, the regional healthcare service provides benefit from the centrally available patient data and can take advantage of the electronic telemedicine data that is produced by patients almost as a "by-product" while they use the SHB to get individual support and individualized information. Since all potential stakeholders in an HSN were considered, the coordination service concept can be adapted to other chronic diseases.

Implications

The developed service addresses one of the three large challenges in stroke care: the individual yet not comprehensive support of patients and inter-related service providers along the complete patient care pathway in an HSN. However, the effect has only been validated in workshops and has not been shown in real-world scenarios. Thus, the developed service concept that improve HSQ in an HSN is only of theoretical nature. They have also been developed in a single case study setting, which might impair the service concept's generalizability. Even though stroke is

Requirement	Covered by
S1 Independent access	provided by CRM and SHB
S2 Connection to existing data(bases)	provided by CRM and PMR
S3 Workflow management system	provided by CRM
S4 Mobile component	provided by SHB
S5 Connection to telemedicine devices	provided by SHB
S6 Hardware security measures	provided by SHB
P1 Affect complete patient care path-way	inpatient and outpatient phases included
P2 Person-oriented	individual support through stroke manager
P3 Home visits	incorporated in outpatient workflow
P4 Contact to all involved stakeholders	connection to CRM data, usage of SHB
P5 Sophisticated ICT support	provided by CRM, PMR, PHR, and SHB
P6 Patient consent	incorporated in inpatient workflow
L1 Access and disclosure control	provided by CRM architecture
L2 Replicable documentation	provided by CRM architecture
L3 Few data sets	combination of PMR and PHR
L4 Pseudonymization	provided by overall ICT
L5 Encryption	provided by CRM and SHB implementation

Table 4.7: Summary of the requirements covered by the developed stroke-specific coordination service.

a complex disease, which – in theory – allows the concept to be adapted to other chronic diseases, this can not be taken for granted. To provide evidence for practical suitability of the coordination service concept, it has been implemented and evaluated in a real-world scenario. In the following chapters, long-term evaluations of the coordination service’s stroke-specific instantiation are presented. Thus, the following Part III relates to Research Question 3 that addresses these long-term effects of a coordination service on HSQ in an HSN.

Part III

Evaluating the Coordination Service Concept

Chapter 5

Service Evaluation Methodology

The rationale behind this work is to improve coordination between independent stakeholders in a healthcare service network (HSN). It particularly focuses on patients suffering from a chronic disease that need multiple healthcare service providers. It investigates a coordination service with the goal to improve information flow in the network and decrease existing information asymmetries between stakeholders. Ultimately, the service is supposed to increase HSQ from a network perspective. In order to achieve this goal, a coordination service concept was designed accordingly. A service engineering approach was devised that comprises service design and service management, i.e. service evaluation. The service's requirements, performance standards, and derived characteristics have been described in Part II: Chapter 3 and Chapter 4 presented the service design methodology and the service design itself, respectively. The coordination service has been prototypically created for stroke as *stroke manager service concept*. Using a case study methodology, the service's configuration has been conceptually validated as described in Section 4.2 and instantiated for a stroke-specific case in doing so.

Part II presents, how the coordination service has been developed, instantiated, and validated. In Part III, the evaluation regarding the service's long-term impact is presented. This relates to Research Question 3. It deals with the impact of the coordination service when it is applied in a real-world scenario. In detail, Research Question 3 investigates the impact of the service's effectiveness, efficiency, and acceptance. Following the devised engineering approach, the service is evaluated in a real-world environment during the second phase, i.e. the service management phase. As depicted in Figure 5.1 this second phase consists of implementing the service, measuring its performance, assessing the customer's satisfaction with the service, and concluding with possible service performance improvements. The first stage of this phase, the implementation phase, is the transition stage between service design and service management (Ramaswamy, 1996). Thereafter, the service's

performance is measured using interviews, questionnaires, and primary data drawn from the used ICT. These first two stages are part of a field study, whose setup is presented in this chapter. Evaluation results and implications from the last two stages of the service management phase are reported in Chapter 6.

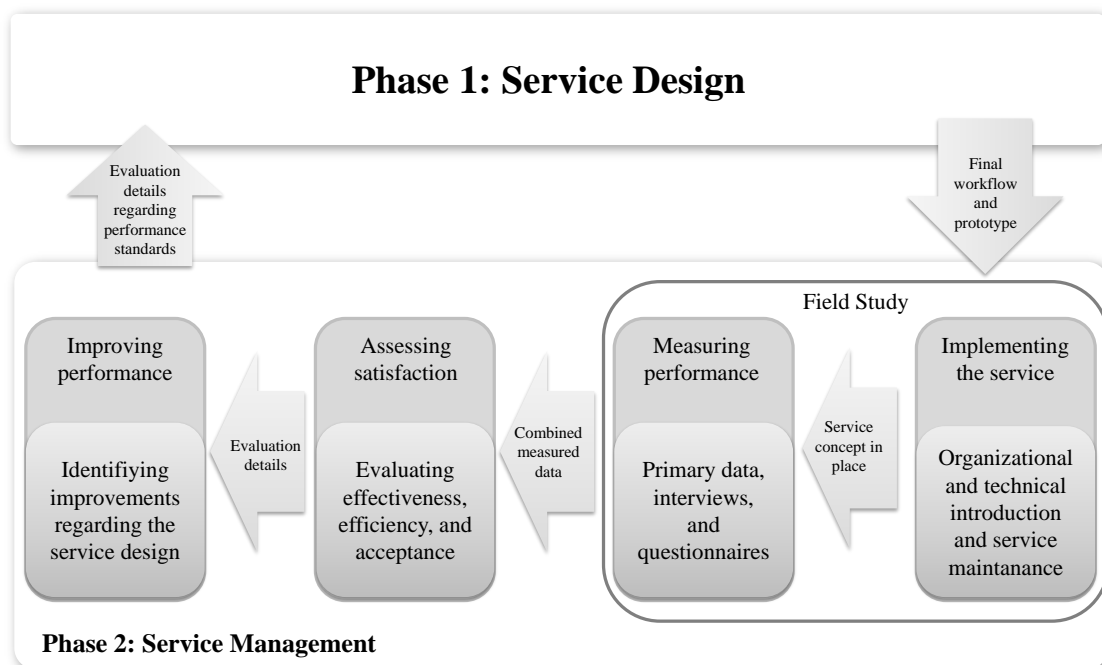


Figure 5.1: Illustration of the stroke manager service management part during which its effectiveness and efficiency are evaluated.

This chapter presents the considerations of the first two service management stages in more detail, whereas the following chapter, Chapter 6, presents the results of the service performance evaluation and its implications. Thus, this chapter provides insights into the evaluation methodology of the stroke manager service concept. The service is evaluated in a field study to measure its effects regarding the HSQ in a real-world setting. This approach was chosen because the complex interdependencies of introducing a coordinating service such as the stroke manager service into a network of independent healthcare stakeholders, i.e. healthcare service network, is difficult if not impossible to capture in an artificial setting. Therefore, a randomized controlled trial (RCT) (Schulz et al., 2010) with a parallel intervention/control-study design was administered. Since the stroke manager service makes use of ICT, the reporting is based on the "statement on reporting evaluation in health informatics (STARE-HI)" guidelines developed by Talmon et al. (2009). The first section describes the field study in general with respect to its background, objectives, goals, and study characteristics. The second section presents the specific study design including the study's organizational setting, used ICT and participants, population's characteristics, flow. The third section introduces the analysis methodology and describes the methods for data acquisition and data analysis. Be-

fore presenting the results in Chapter 6, the last section of this chapter summarizes the service evaluation methodology.

5.1 Study Setting

The impact of the coordination service was evaluated in a field study to capture the long-term effects. A field study is an experiment in a "natural setting," in which unprepared participants are observed (Yin, 2008). If participants are not in a natural setting, they might alter their habits or usual procedures distorting the study results. Even though – from a scientific point of view – a field study has the major disadvantage of uncontrollable variables, it has the advantage of capturing characteristics that have not been identified previously. Particularly, these unknown characteristics are of interest because the healthcare service networks and the interdependencies between the different stakeholders are very complex. As stated by Hammerschmidt et al. (2012) and described in Chapter 2 it is difficult to use theoretical approaches for modeling HSNs such as simulations to yield valid results. Therefore, the field study approach was chosen. This section describes in more detail the field study's rationale, objectives, and characteristics.

5.1.1 Study Background

In the medical field, it is common knowledge that better secondary prevention, such as regularly measuring blood pressure, or timely rehabilitation has a positive effect on stroke patients' health (Schlote et al., 2008; Langhorne et al., 2011). Furthermore, better coordination in terms of patient empowerment and information sharing across organizational boundaries also has a positive effect on stroke patients' health (Kjellström et al., 2007; Bodenheimer et al., 2002). Regarding patient empowerment, McCullagh et al. (2005) and Langhorne et al. (2011) have shown that if stroke patients' information demand about their disease is fulfilled, they perform better secondary prevention and have better long-term health status. Many patients do not actively disobey guidelines for stroke rehabilitation but rather do not know that they exist. Furthermore, patients that are individually supported in their rehabilitation phase, generally accept this support eagerly and have better outcomes (Teasdale and Jennett, 1974). The same holds true for the healthcare service providers. In case of service over-, under-, or mis-use, they often lack information that enable them to provide the right service in the right quality (Johnston, 2004). If healthcare providers were supplied with necessary information without any additional effort on their part, they will use these information.

This study was based on the aforementioned and well-known interrelation between adequate post-acute treatment, such as secondary prevention or regular rehabilitation, and stroke outcome. It did not investigate this relationship, but rather focused on evaluating effects of the stroke manager service concept on secondary prevention and regular rehabilitation, which in turn are proven to foster patient health. In doing so, this field study addressed the comprehensive Research Question 3 regarding the socio-technical service's impact. Since the coordination service was developed as a socio-technical service, it comprises two major parts: a person – the stroke manager – and the underlying ICT. Particularly for the acceptance evaluation, both parts are investigated separately.

5.1.2 Study Objectives

The objective of the study was to address Research Question 3: What is the impact of the coordination service in a healthcare service network? This comprehensive question, which the study investigated in detail, is divided into the three sub questions: 1) the service's effectiveness regarding healthcare service quality, 2) the service's efficiency, and 3) the acceptance of the involved patients. Furthermore, from a medical point of view, the study was supposed to provide insights in how to improve healthcare service quality provided for patients suffering from a stroke. In the following paragraphs, the research hypotheses for the three sub questions are introduced.

The used metrics for each of the three sub questions addressed in the field study are shown in Table 5.1. For the effectiveness evaluation, the metrics are based on the determinants of HSQ in an HSN that have been presented in Section 2.1. The two major HSQ categories are patient health, which is essentially the outcome quality, and the healthcare delivery quality, which is constituted by patient self-management competences and the timely utilization of healthcare services. During the service development phase (see Section 4.1), stroke-specific determinants from these categories have been identified that serve as performance standards for the coordination service. The research hypotheses of the effectiveness sub question of Research Question 3 were based on the stroke-specific determinants. For efficiency and acceptance, commonly accepted metrics of cost-output-ratio and customer acceptance were used as basis for the research hypotheses. Both metrics are described in more detail in Section 5.3.3 and in Section 5.3.5 of this chapter, respectively.

As argued in Section 4.1, patient self-management competences depend on the structural determinant of available information after discharge and the process determinants of adherence to secondary prevention. In line with the propositions of NSA (2006), Kjellström et al. (2007), and Schlote et al. (2008), the level of information after discharge was determined by inquiring the patients' knowledge about two

Sub question	Metric
Service effectiveness	Patient self-management competences (PSMC)
	Timely utilization of healthcare services (TUHS)
	Patient final outcome (FO)
	Patient intermediate outcome (IO)
Service efficiency	Cost-benefit-ration (CBR)
Service acceptance	Costumer acceptance (CA)

Table 5.1: The field study's underlying metrics.

determinants: 1) the situation after leaving the hospital and 2) the available outpatient supporting services. The non-medical secondary prevention was determined by the frequency the patients drink alcohol, are physically active, and measure their blood pressure (NSA, 2006; Kjellström et al., 2007; Bodenheimer, 2008; Myint et al., 2011). The often used indicators of therapy adherence and smoking cessation were not used because they were too complex to inquire and dependent on additional addiction therapy, respectively. Therefore, the following three research hypotheses for the patients that are supported by the stroke manager were postulated:

- PSMC-1 The patients supported by the stroke manager have more knowledge about their situation after leaving the hospital.
- PSMC-2 The patients supported by the stroke manager know more outpatient supporting services.
- PSMC-3 The patients supported by the stroke manager perform better non-medical secondary prevention.

The timely utilization of the available healthcare services focused on the transition between the hospital to the home environment. According to the definition of the determinants in Section 4.1, these does not only include structural components, like the provisioned aids, but also the processes like the idle time between the rehabilitation phases. On the one hand, it targets the healthcare service providers and their information provision. This is determined by the seamless transition between the treatment phases (Hensler et al., 2007; Bodenheimer, 2008). On the other hand, it also incorporates the patient as co-producer of the healthcare service quality by investigating if the patients make more use of the available supporting services. This is determined by the adequate provisioning with aids and the usage of healthcare services after discharge, i.e. the social service and the outpatient supporting services

(Hensler et al., 2007; Kjellström et al., 2007). Thus, the following research hypotheses were postulated for the second metric:

- TUHS-1 The patients supported by the stroke manager have less idle time between the rehabilitation phases.
- TUHS-2 The patients supported by the stroke manager are better provisioned with additional aids, like wheelchairs etc.
- TUHS-3 The patients supported by the stroke manager visit the social service more often.
- TUHS-4 The patients supported by the stroke manager utilize more outpatient supporting services.

In contrast to the first two metrics that focus on the healthcare delivery quality, the third and fourth metric focus on the stroke manager service concept's effect on the patient health specifically. According to the findings reported in Section 4.1, the final patient outcomes are determined by the indicators mortality, level of care, and re-occurrences (Hensler et al., 2007; Kjellström et al., 2007; Bodenheimer, 2008). The following research hypotheses were thus postulated:

- FO-1 The patients supported by the stroke manager have lower rates of mortality.
- FO-2 The patients supported by the stroke manager have a lower classification of their "level of needed care".
- FO-3 The patients supported by the stroke manager have lower rates of re-occurrences.

The fourth metric considers more functional measures, such as medical scales, that serve as instruments to create intermediate indicators. According to the findings reported in Section 4.1 of Part II, these intermediate indicators for patient health are activities of daily living (ADL), functional abilities, and health-related quality of life (HRQOL) (Hensler et al., 2007; Kjellström et al., 2007; Bodenheimer, 2008). Thus, the corresponding research hypotheses were postulated:

- IO-1 The patients supported by the stroke manager have better scores on scales regarding activities of daily living (ADL).
- IO-2 The patients supported by the stroke manager have better scores on scales regarding functional abilities.

- IO-3 The patients supported by the stroke manager have better health-related quality of life (HRQOL).

In addition to the service concept's effectiveness, the aspects of efficiency and acceptance were also considered in the study. The fifth metric involves the cost-benefit-ratio to elaborate the stroke manager service concept's efficiency. The following research hypotheses are based on the assumption that the stroke manager service is financially worthwhile for the HSN. The current case management literature serves as a basis for the hypotheses that the stroke manager has a positive cost-benefit-ratio for hospitals depending on the amount of patients the stroke manager supports. For example, Crawley (1996) state that a case manager can handle approximately 50 patients per year. Since the designed coordination service incorporates ICT, the number of patients that can be supported is assumed to be higher.

- CBR-1 The stroke manager service is profitable from a hospital perspective.
- CBR-2 The stroke manager service is profitable from a societal perspective.

The sixth metric involves the acceptance of the service's customers, i.e. the involved stakeholders. If the coordination service, e.g. the technical components or the collaboration with the person stroke manager, are not accepted by the involved stakeholders, the service might not unfold its full effect. Therefore, even though acceptance is not the most important factor, it is still investigated. The research hypotheses pose that the involved stakeholders, i.e. patients and healthcare service providers, accept the stroke manager service.

- CA-1 The stroke manager service is accepted by the supported patients.
- CA-2 The stroke manager service is accepted by the involved healthcare service providers.

Since the devised field study involves actively influencing patients and possibly their health, the study needed an ethical approval (Schulz et al., 2010). An ethical committee of the involved hospital has therefore reviewed the overall study approach, its means for conducting the study, and the posed research questions. In doing so, a panel of experienced physicians verified the research agenda, including data acquisition methods such as surveys or clinical data, to ensure their validity and clarity. The ethical committee consisted of several senior physicians and assistant medical directors who have granted ethical approval to the study registered as NKG-FB VW 030-B-11-06 in January of 2012. Part of these ethical considerations was that the patients had to be informed and their data had to be processed correctly. At the point of inclusion, the participating patients were informed personally and

also by means of an information brochure about all aspects of the study. While patients were especially briefed with respect to legal aspects and the study procedure, they were not informed about the study's scientific goal to prevent any bias. Privacy of participating patients was protected, and all data was coded and processed in pseudonyms. It was made clear in the informed consent form that each patient can terminate his or her participation in the study at any moment without the care being influenced.

5.1.3 Study Characteristics

In healthcare, particularly in healthcare service research, regarding the effects, an important distinction is made between efficacy and effectiveness of health services (Schulz et al., 2010). Effectiveness describes how well an intervention works in practice, in community settings including the full range of individuals that might have multiple diseases or inflict other cross-related effects. Measuring effectiveness deals with the question of who will benefit from the intervention among the people in a certain community suffering from a specific disease. In contrast, efficacy denotes the interventions' impact on the patient outcome in clinical trials that allow isolating the measured effects as detailed as possible. Simply speaking, efficacy is effectiveness of an intervention in a controlled setting with, for example, a limited group of test persons possessing specific characteristics. Obviously, both efficacy and effectiveness are important questions regarding an intervention, and, logically, effectiveness should be investigated after finding an intervention to be efficacious. However, due to ethical reasons, pure efficacy studies are not always feasible. If a treatment is undoubtedly advantageous, it is difficult to argue that some patients are deprived of it only to show that other patients are doing better.

In Part II the stroke manager service concept has been – in theory – attested a positive effect on the healthcare service quality in the healthcare service network by means of qualitative evaluation. Since its effects have not been studied in real-world settings and, thus, its efficacy has not been confirmed yet, a controlled setting is needed to attribute the measured, quantitative effects to the stroke manager intervention specifically. Therefore, a randomized controlled trial (RCT), which is viewed as the standard procedure for clinical trials (Schulz et al., 2010), was chosen as method for conducting the field study. Because the main goal was to investigate the stroke manager service's efficacy, the RCT has an exploratory character. The RCT was conducted as clinical trial with randomized patient allocation to two parallel groups, of which one is the study group with patients taking advantage of the stroke manager service and the other one is the control group in which patients receive the "usual care." The randomization was applied to eliminate bias in treat-

ment assignment and, thus, facilitating the use of probability theory to express the likelihood that any difference in outcome between the two study groups are only apparent by chance.

Though RCTs are seen as the standard procedure for clinical trials, they have several drawbacks that had to be considered during the field study (Schulz et al., 2010). One major drawback is external validity. Even though its external validity is better than in theoretical approaches like simulations, the location of the RCT may have a strong bias, which makes it hard to generalize results to other regions or countries. Furthermore, participants' selection, which needs to be restricted to evaluate efficiency, might result in effects that only turn up in this particular setting. In addition, in this setting the stroke manager service characteristics induced another drawback. Control group patients might have learned of the stroke manager service, and, due to ethical reasons, simply providing "usual care" could not be fully maintained. Therefore, the RCT could not be designed to be fully controlled. Nevertheless, it was the best option to evaluate the stroke manager service effects in a real-world situation, and during analysis possible biases were taken into account.

5.1.4 Study Sample

Study participants were stroke patients recruited in a hospital that is specialized on neurological acute treatments. Patient population consisted of stroke patients who were admitted consecutively to the hospital during a six month period from July 2012 until December 2012. Diagnosis of stroke was made by neurologists based on patient history, physical examination, and neuro-imaging at the hospital. Before the study commenced, several issues regarding the RCT's conduct were elaborated: First, inclusion and exclusion criteria for study participants were defined; second, the type of randomized participant allocation were agreed upon; and third, sample size, i.e. the number of necessary participants needed to produce significant results, were calculated (Talmon et al., 2009; Schulz et al., 2010).

To achieve a homogeneous patient cohort that allows valid research findings, patients were only included in the study if they met strict inclusion and exclusion criteria. The following clinical criteria were applied that are stated in the literature (see for example (Schlote et al., 2008; Talmon et al., 2009; Heuschmann et al., 2010)) and have been confirmed by involved physicians.

- Patients have to be older than 18 years or younger than 90 years at stroke incident. This increases the probability of excluding patients that have exceptionally complex health conditions.

- The incidence has to be the patient's first ischemic attack, i.e. stroke. Otherwise patients might be influenced by information they received in stroke treatments they had before.
- Patients suffering from a transitory ischemic attack (TIA) are not included because they are not necessarily impaired by the stroke at the first point of the intervention.
- Patients should not have other diseases that are expected to result in death the next 12 months, such as lethal tumors.
- Overall, patients are not allowed to have another severe condition apart from stroke, like congestive heart failure, that would obviously influence their health strongly;
- Apart from not having other severe diseases, patients are not allowed to be afflicted by stroke in a way that there was no chance of rehabilitation and, thus, taking advantage of the stroke manager service. To create an objective criterion for this, patients need to have a Barthel-Index score higher than 30 after acute treatment.

Apart from clinical criteria that guaranteed a homogenous patient cohort in terms of patient characteristics and patient health, there are inclusion and exclusion criteria that aim at securing a homogenous process. Following general criteria are applied to ensure that patients have the same general characteristics to be able to take advantage of the stroke manager service.

- Patients have to be admitted to the hospital with emergency medical service.
- Patients live less than 30km away from the stroke manager's office.
- Patients have to be able to speak German fluently in order to communicate with the stroke manager.
- Patients should not be involved in other clinical trials because of unpredictable side effects.

If patients were eligible to take part in the study according to inclusion and exclusion criteria, they were randomly assigned to study group or control group. A simple randomization was used, which means that eligible patients were assigned to the two groups alternately. This approach tends to create imbalanced group sizes due to different drop out rates but more sophisticated randomization procedures are impractical because of fast acute-treatment processes in stroke care. The treatment process is also responsible for the applied RCT not being double blind, which

means that neither patient nor physician know what group the patient belongs to. It was only single blind in a way that patients do not know if they belong to control or study group, whereas the healthcare service providers can tell the different groups apart.

After describing the inclusion and exclusion criteria as well as the randomization, the third study characteristic, the sample size, is looked at in detail in the following paragraphs. The sample size signifies the number of participants in a study. The sample size calculation, which is performed to determine the number of participants necessary to detect a relevant treatment effect, is one of the first and an important – if not the most important – step in designing a study (Noordzij et al., 2010). If the sample size is too small, one may not be able to detect an important existing effect, whereas samples that are too large may waste time, resources, and money (Phillips, 2003).

The sample size is affected by four factors: The possible magnitude of the effect differences; its desired level of significance; its desired level of power; and the type of hypothesis. The formula for sample size calculation differs depending on the type of study, e.g. parallel or cross-over group settings, and the evaluated outcome type, for example comparing two means of continuous scales or binary values such as mortality. Since the stroke manager service RCT aimed at evaluating the differences in HSQ between a study ground and a control group, the sample size can be calculated as follows (Phillips, 2003; Noordzij et al., 2010):

$$(5.1) \quad n = 2 \frac{(Z_{\alpha/2} + Z_{1-\beta})^2 \sigma^2}{(\mu_1 - \mu_2)^2}$$

In Equation (5.1), n denotes the sample size considering study and control group. $Z_{\alpha/2}$ is the critical value for a 2-tailed t-test at a certain level of significance regarding the type I error, e.g. the critical value $Z_{\alpha/2}$ equals 1.96 for 5% level of significance. Since the difference in treatment is investigated, be it better or worse, a 2-tailed α is assumed. $Z_{1-\beta}$ denotes – similar to $Z_{\alpha/2}$ – the critical value at $1 - \beta\%$ power regarding the type II error. The populations' variance and standard deviation are signified by σ^2 or σ , respectively. The two variables μ_1 and μ_2 denote the population mean of the investigated outcome in the study group and the control group, respectively. Thus, $\mu_1 - \mu_2$ is the effect size that is likely to emerge during the study.

When the sample size for the stroke manager service RCT was calculated, according to Armitage et al. (2008) the common 0.05% significance and 80% power were postulated and the parameters were chosen accordingly. Determining the effect size and its standard deviation, however, was challenging. Since the goal of the stroke manager service is to improve healthcare service quality in a network of independent stakeholders, the effect size could not be described in a single value. For most

of the different indicators of healthcare service quality, e.g. patient self-management competences or utilized services, there are no well-recognized parameters that could be used to describe the effect size.

One of the stroke manager service's primary goals is to increase the patient's HRQOL along the complete care pathway. Therefore, the health-related quality of life HRQOL, which has been investigated in several previous studies, was used as the reference effect size for the sample size calculation. The three usual ways to acquire the effect size are: 1) from past literature; 2) from a small pilot study; 3) from clinical expectations (Suresh and Chandrashekara, 2012). For the RCT at hand, past literature was chosen. Based on earlier studies among stroke patients, the difference in utilities indicating health related quality of life between study and control group are assumed to be 0.11 with a standard deviation of 0.19 (see for example (Olsson and Sunnerhagen, 2006)). Based on the power and significance assumption above, the study sample needs to be 47 participants per group. Similar to other studies, a drop-out rate of 12.5% because of patients that terminate their participation, patients' inability to cooperate or mortality. Thus, the number of participants necessary to achieve significant results was increased to 54 per group. Overall, the study sample should include 108 stroke patients that satisfy the inclusion and exclusion criteria.

5.2 Study Design

After describing the field study and the associated study context regarding the stroke manager service concept in the region of Rhön-Grabfeld in the previous section, this section deals with the detailed study design. First, the overall study design, the context of the randomized controlled trial (RCT), is introduced. This includes a detailed description of the site in which the field study took place and the used materials which were used during the field study. Second, the study flow is presented with a clear description of beginning and end of the intervention.

5.2.1 Study Context

The field study and, thus, the evaluation of the stroke manager service concept took place in a rural area in northern Bavaria in Germany. Figure 5.2 illustrates the administrative district "Rhön-Grabfeld" and the surrounding districts. It is the area of the investigated healthcare service network, in which the stroke manager service concept was introduced. The red dot marks the exact location of the hospital, the Neurological Clinic Bad Neustadt a.d. Saale (NBN), from which all the study par-

ticipants were recruited. The NBN provides emergency treatment in an emergency department, the neurological acute treatment with stroke and other intensive care units, several rehabilitation wards, and additional ambulatory treatment¹. Overall it has 271 patient beds, from which 61 beds are reserved for the acute treatment, 89 beds for early rehabilitation, particularly for major head injuries, 48 beds for the continuous rehabilitation, and 73 beds for the inpatient and ambulatory follow-up treatment. Apart from the medical personnel, the hospital also has a social service with three full time equivalents social workers that are in charge of the discharge management and support the patients' transition from inpatient to outpatient treatment to some extent. However, neither the NBN nor any organizations from the area provide a case management or other management program for stroke patients (see Section 3.3). Since the NBN maintains a certified, trans-regional stroke unit and uses the Stroke Angel System (Ziegler et al., 2008), it treats most stroke patients in near vicinity. Therefore, the possible study population was expected to be similar to the general stroke patient population in the region.

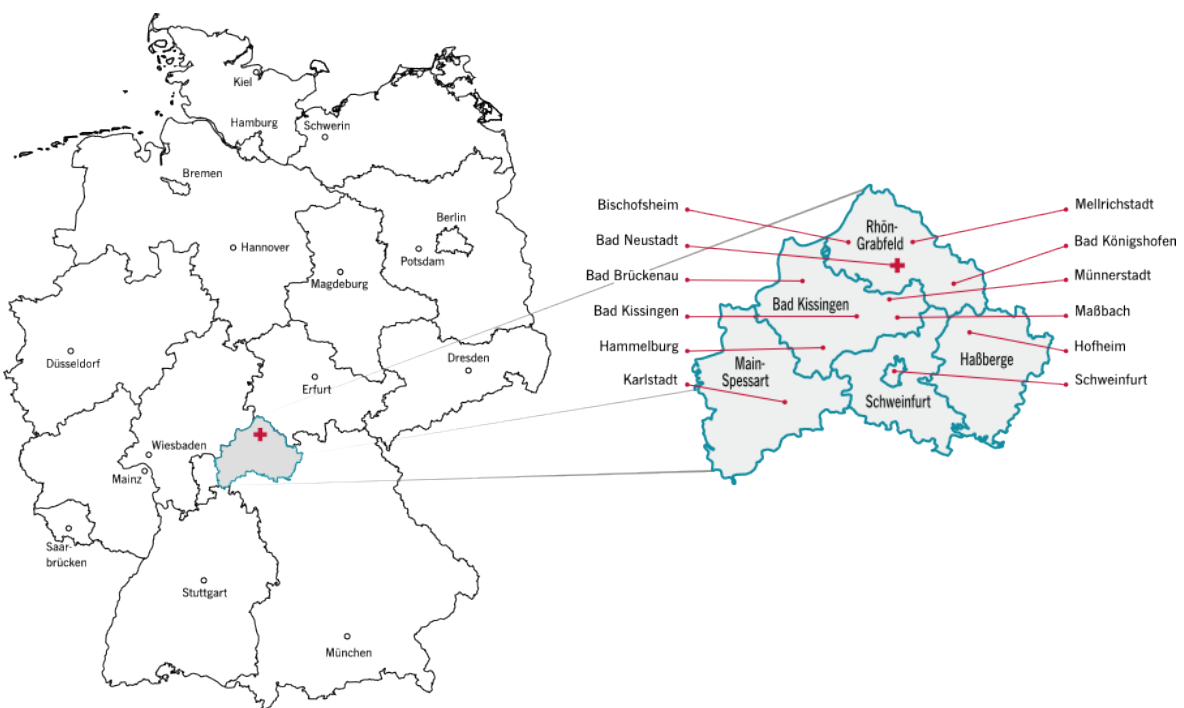


Figure 5.2: Illustration of the region in Germany in which the field study is located. The red cross indicates the hospital's exact location.

In addition to the hospital, the field study also incorporates the local healthcare providers in the mentioned region of Rhön-Grabfeld such as occupational therapists, speech therapists, general practitioners, neurologists, ambulatory medical services, or ambulatory social services. In contrast to the explicitly included hospital, these regional outpatient healthcare service providers are not exclusively included

¹See http://www.rhoen-klinikum-ag.com/rka/cms/nkg_2/deu/51884.html for details

in the study. All the stroke patients have to receive the acute treatment in the hospital, whereas the mentioned outpatient healthcare service providers are rather elective along the complete stroke patient care pathway. Nevertheless, they are stakeholders in the healthcare service network (see Subsection 2.2.3 for details), and are, therefore, possibly included by the stroke manager service concept.

For the field study, the stroke manager service including the ICT-structure was implemented in the healthcare service network of the mentioned region. To alleviate some of the legal constrictions in the study phase, the service was based in the hospital providing acute treatment. This allowed the stroke manager to easily access initial patient information that are gathered during the acute stroke treatment, and to fit in the existing processes and ICT-structure without additional effort. Otherwise, the stroke patients or their relatives have to give their consent to allow the stroke manager actually asking them to offer the individual support, which most patients at that point of time are cognitively not able to do.

The stroke manager service has been implemented in the NBN at the beginning of 2012. A detailed time line of the stroke manager's implementation course can be found in B.1. After the approval of the ethic committee in January 2012, the ICT-structure was introduced according to the implementation plan. The workflow management software has been set up on a cloud store provider and the hospital firewall has been configured to allow access. In January and February 2012, the stroke manager has been trained on the software, and specific manuals have been distributed. Moreover, a one month pilot phase with one typical stroke patient and the care-giving relative has been administered. A software connection between the coordination service ICT-structure and the hospital information system has not been implemented, but the stroke manager has manual access to the available data. The ICT for the patients, the stroke health books (SHBs), has been packed into sets for them to handle the ICT easily because most patients – if not all – will not have used a tablet PC before. As shown in Figure 5.3, the sets comprise the SHB itself, a bag, a multi-contact plug, a short manual for the quick start, and more detailed manual. Regarding the process changes, the personnel of the hospital has been informed in their regular meetings about the stroke manager. Particularly, the physicians of the stroke unit have been briefed and regularly briefed again that the stroke manager is supposed to support stroke patients and they need to suggest sending the stroke manager to patients they are caring for. Since the outpatient healthcare service providers are not involved with all the stroke manager patients, they have not been explicitly informed but rather been giving general information during local events and gatherings. Furthermore, explicitly briefing the outpatient healthcare service providers would have created a bias in a way that they treated patients from the NBN differently regardless of the stroke manager. The service has been implemented in the regional healthcare service network by introducing the organizational

and technical changes and ensuring the maintenance of the service for a sufficient study period as described by stage one of the second service engineering phase, the service management (see Section 3.2 for details).



Figure 5.3: The complete set with which the electronic stroke health book (SHB) was given to the patients.

5.2.2 Study Flow

The coordination service's impact was evaluated in an RCT that is designed with two parallel groups of patients. The RCT allows comparing the healthcare service quality between patients that took advantage of this intervention, the study group, and patients that received the "usual care," the control group. A flowchart of the RCT illustrates the differences in treatment between patients from the study and control group (Figure 5.4). In the beginning, both, the control group and the study group, received the same acute treatment followed by immediate rehabilitation treatments. Afterwards, the stroke manager started taking action and the difference between study and control group become inherent.

As depicted in Figure 5.4 the study's observation period encompasses the three phases along the patient care pathway: Inpatient phase; Transition phase; and Out-patient phase². The patients were supported starting from their stroke incident until 12 months afterwards. The data was acquired from both groups at three points in time (T0, T1, and T3) with additional data acquired only from the study group at T2 (see Figure 5.4). Regarding the data acquisition, the study design follows other studies with stroke patients, which acquired data three and twelve months after the

²Refer to Section 3.3.4 for more details about medical characteristics of the stroke care pathway.

stroke incident (Heuschmann et al., 2010; Wissel et al., 2011; Cameron et al., 2008). Allegedly, the stroke patient's condition changes most in this time frame (Hensler et al., 2007; NSA, 2006). At the end of the acute treatment (T0), socio-demographic, administrative and general clinical data from the hospital stay were obtained. Even though it would have been valuable data, data provided by stroke patients themselves immediately after they had their stroke is unreliable because of their psychological state and often prevalent cognitive impairments (Heuschmann et al., 2010).

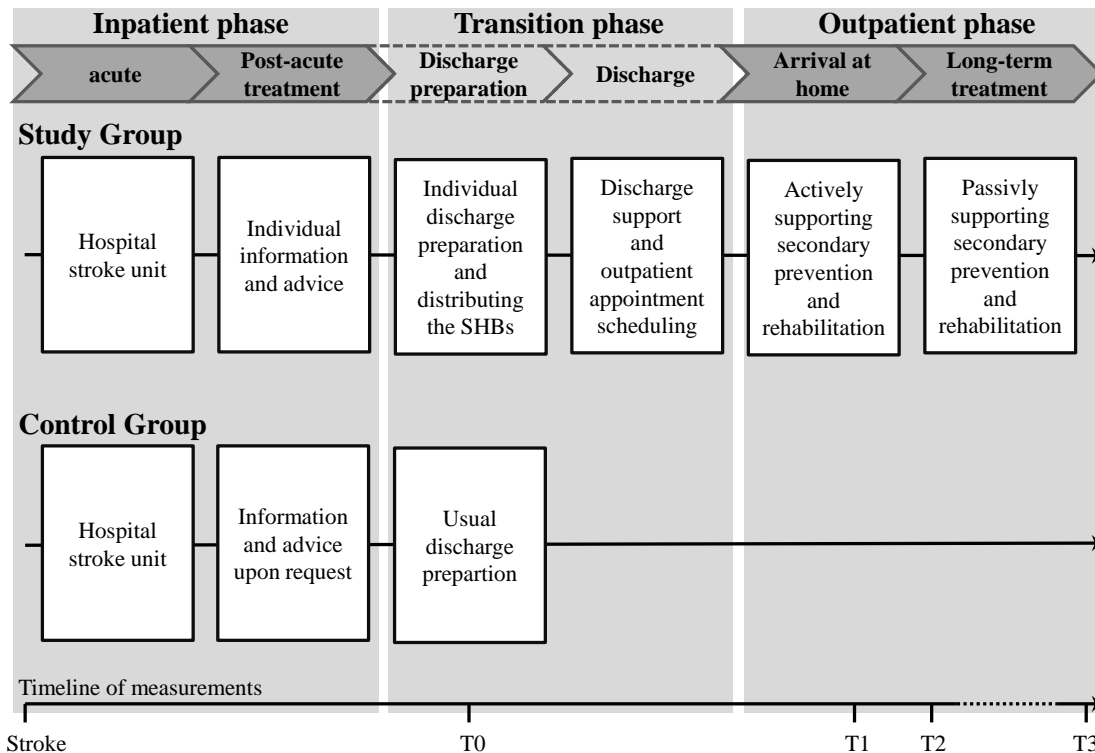


Figure 5.4: Flowchart of the stroke manager field study illustrating the differences in treatment and the points in time (T0-T3) when data was acquired.

Three months (T1) and twelve months (T3) after the successful acute treatment, a stroke follow-up took place and data regarding the patients' current situation was collected, e.g. current living conditions, needed level of care, level of available information, health-related quality of life, and possible activities of daily living. This data acquisition was a two-staged process including a first contact via telephone and a subsequent paper-based questionnaire. This two-staged process is supposed to provide a high response rate, which is necessary because of the small number of participants in the study overall. Furthermore, additional data was collected from the study group three months after being discharged from the hospital (T2). At this point, the patients of the study group were asked to fill out an additional questionnaire to provide more data regarding their attitude towards the stroke manager service for assessing the service acceptance from the patient side. Depending on the

length of inpatient treatment, which is in case of a "mild stroke" only seven to ten days, the study group questionnaire at T2 was close to the three months follow-up at T1.

During the stroke manager field study the observation focus was put on patients, their relatives, and the involved healthcare service providers like hospital personnel or outpatient therapists, general practitioners etc.. After the successful acute treatment (T0), the patients that were supported by the stroke manager, received individual information whereas the "usual care" generally consisted of information upon request. The individualized information provision took the severity of the stroke, the time passed since the stroke occurred, and other individual factors into account. This individualized information provision was followed through along the complete stroke patient care pathway until T3, i.e. in inpatient and outpatient settings as well as the transition phase. In contrast to the control group, the study group has gotten an individual discharge preparation, first outpatient appointments are scheduled, and further support is offered during the outpatient phase. Particularly, during the first three months of the outpatient treatment, until T2, the stroke patients, their relatives, and the involved healthcare service providers were coordinated actively. The patients, if their cognitive and motor skills allowed the usage, were given telemedicine devices like the stroke health book (SHB) and receive, if necessary, home visits while being supported regarding secondary prevention and rehabilitation. As described in Section 4.2.4, the stroke patient was given the choice between using electronic SHB and not using it. The SHB does not only display the information electronically but also provides an integrated blood pressure device, a personalized calendar, and a means for the stroke manager to influence and record the patient's adherence more directly. From three months after hospital discharge (T2) until 12 months after the stroke incident (T3), the patients were supported passively, i.e. information and advice is given upon request. In this phase, the telemedicine devices and home visits were not used anymore.

After implementing the stroke manager service in the beginning of 2012 (see Section 5.2.1), the study started in March 2012. Even though the personnel was trained, the software tested beforehand, and the procedure were thoroughly discussed with experts, several technical and organizational issues arose. From a technical perspective, it became evident that the instruction and training during the implementation phase was not sufficient. Thus, the stroke manager had a steep learning curve during the first months, and provided patients with significant better information after the first months as well as providing better data documentation.

From an organizational perspective, there were two major issues regarding the conceived workflow. First, in contrast to the initial analysis, there were not many patients that qualified for the strict inclusion criteria. After consulting the physi-

cians in charge of the field study in the hospital, the inclusion criteria were softened. For one thing, the strict inclusion criterion that patients have to arrive at the hospital using emergency medical services was dropped. An additional analysis proved that it had no effect on the stroke's severity. In addition, recruiting the patients did not work as intended because after an initial phase of several weeks, the responsible physicians of the stroke unit did not include patients in the study anymore. Allegedly, they were too busy with their regular work to be able to keep the study in mind. In June 2012 the inclusion and exclusion criteria were adapted and the study inclusion was only performed by the head physicians in charge. Thus, only data from patients being included in the study from July 2012 until December 2013 were used for the evaluation.

5.3 Data Acquisition and Analysis

After presenting the service setting and design in the previous sections, this section deals with the data acquisition and analysis of the coordination service evaluation. This section describes the methods for data acquisition and analysis during the evaluation of the coordination service in the randomized controlled trial, which was used to answer Research Question 3. The research question aims at investigating the long-term impact of the coordination service regarding its *effectiveness*³ and *efficiency*. In addition, service's *acceptance* was assessed in order to evaluate the incentives that have been devised. Results of the coordination service evaluation provides researchers and practitioners with insights in how to improve coordination in healthcare service networks.

For the assessment, case study techniques such as interviews and surveys were incorporated in a field study with two parallel patient groups: One study group that received the intervention and one control group that received the "usual care." To assess the coordination service's impact in the HSN, the differences between "usual care" and intervention group were analyzed. The *effectiveness* analysis is based on the HSQ metrics for an HSN are applied that have been proposed in Section 2.1.2 and, subsequently, been broken down into further detailed measures in Chapter 4. To evaluate the coordination service's *efficiency* its incremental cost effectiveness was compared to the "usual care" provided. This evaluation involves a cost-utility-analysis, in which costs were assigned to the achieved outcomes. The health economic evaluation signifies transferring and utilizing economic methods in healthcare but does not intend to economize healthcare because this involves several ethical debatable decision, which are not part of this evaluation. Furthermore, the *acceptance* of the coordination service was evaluated. The *acceptance* is important to

³See Section 5.1.3 for a detailed overview of differences between effectiveness and efficacy.

evaluate apart from *effectiveness* and *efficiency* because if the service is not accepted by the stakeholders, they will not cooperate.

In the next subsections, the methodology is described. The first subsection deals with fundamentals of health economic evaluation. Afterwards, the methods of data acquisition for the *effectiveness* are described. This includes presenting the instruments for measuring the healthcare delivery quality and patient health. In Section 5.3.3, the used means of measurement for *efficiency* of the coordination service are presented. The costs are derived from the existing maintenance costs of the stroke manager service. Utility is evaluated in two different ways. First, costs are related to final patient outcome indicators and their implications. For example, costs are related to saved expenditures of prevented stroke re-occurrences or other re-hospitalizations. Second, utility is approximated by intermediate patient outcome proxies, which measure patients' health-related quality of life. After the instruments for *effectiveness* and *efficiency*, the *acceptance* evaluation is presented. First, fundamentals of technology acceptance in healthcare are introduced. Then, the *acceptance* evaluation is presented. It consists of two parts: Patients and healthcare service providers. On the one hand, the study group's opinion about the coordination service's ICT-architecture and the developed processes was inquired. On the other hand, the healthcare service provider's experience with the study group was assessed as well as the stroke manager's expert knowledge. The section closes with two subsections about the general statistical analysis methods used and a summary of the study methodology, which includes results of a pretest.

5.3.1 Fundamentals of Health Economic Evaluation

For evaluating the efficiency of the coordination service, the input and the output have to be put into relation to each other. In health economics, there are several evaluation methods, which differ regarding the number and nature of the outcome measures, the number of incorporated input measures, and the type of comparison used. Next to pure cost-comparison analyses, there are three methods that are most commonly applied (Drummond et al., 2005): 1) Cost-benefit-analysis (CBA); 2) cost-effectiveness-analysis (CEA); and 3) cost-utility-analysis (CUA). In the literature CEA and CUA are sometimes used interchangeable, but as Drummond et al. (2005) points out, they differ regarding their outcome measure. Furthermore, any type of cost analysis is sometimes, especially in non-health economic literature, generally referred to as cost-benefit-analysis although CBA is a precisely defined type of analysis.

The **cost-benefit analysis CBA** is the classic form of economic evaluation, which is mainly used outside of healthcare (Schöffski and von der Schulenburg, 2007).

When using the CBA in healthcare, the "value" of an intervention is particularly characterized by comparing costs and benefits of any treatment in monetary units. In doing so, cost-savings are calculated and it can easily be compared with other treatments in terms of monetary units. In order to be able to perform a CBA, input and output of the investigated medical treatment are monetized. All direct, indirect, and intangible costs are simply subtracted from all direct, indirect, and intangible benefits as illustrated by the following equation:

$$(5.2) \quad I_{CB} = (B_{dir} + B_{ind} + B_{int})(C_{dir} + C_{ind} + C_{int})$$

Direct and indirect costs are calculated straight forward. For example, they include wages, material costs, or overhead. Intangible costs, such as effects of lowered employee morale, are estimated by domain experts to receive a monetary value. In contrast, benefit calculation is more difficult because direct, indirect, and intangible costs have to be assessed by domain experts to provide monetary value for the CBA. For example, differences in quality of life, physical abilities, or mortality rates have to be expressed in monetary units. The CBA's inherent simplicity provides advantages and disadvantages. On the one hand, it allows to compare completely different alternatives. For example, is it more profitable for a hospital to invest in a new medical device or to enlarge capacity. On the other hand, this "monetization" is also seen as provocation because it requires assigning a monetary valuation to certain health states, different age groups, or even human life (Schöffski and von der Schulenburg, 2007).

The **cost-effectiveness-analysis (CEA)** is, in contrast to the CBA, not only based on monetary units but also incorporates medical indicators, e.g. blood pressure, tumor size, or Barthel-Index (Drummond et al., 2005). Treatment effects, i.e. output, are not measured in monetary benefits, but in decline of blood pressure, decrease in tumor size, or increase in Barthel-Index. To measure the effects, generally acknowledged units are used, such as mmHG for blood pressure, millimeters for tumor size, or score points for Barthel-Index. As a result, a cost-effectiveness ratio, e.g. euros per tumor millimeter, can be formed as follows:

$$(5.3) \quad I_{CE} = \frac{(C_{dir} + C_{ind} + C_{int})}{eff}$$

This allows comparing two interventions that aim at the same effect without transforming the effects into monetary units. On the downside, this analysis method does not allow to compare two interventions with different medical outcome parameters. Furthermore, an isolated intervention cannot be assessed if there is no benchmark. Therefore, the CEA was not used for the analysis.

The **cost-utility-analysis (CUA)** addresses the drawbacks of the CBA and the CEA by measuring the interventions' effects in a general outcome utility (Drummond et al., 2005). This general utility does not explicitly provide a monetary valuation and allows comparability across different methods and medical fields. It even allows taking non-medical influences into account. The CUA takes the patient-perspective, which makes it particularly applicable for all patient-centered approaches. Instead of relating the intervention's costs with effectiveness, they are related to patients' utility:

$$(5.4) \quad I_{CU} = \frac{(C_{dir} + C_{ind} + C_{int})}{utility}$$

The CUA captures the patient's utility in terms of quality of life and life expectancy (Drummond et al., 2005). It facilitates healthcare service allocation decisions and intervention evaluation without explicitly assigning human life a monetary value because allows comparing the input (costs) per generic output unit (patient utility) (Drummond, 1987). For this general patient utility, there are manifold measures and one of the most prominent is the quality-adjusted life year (QALY) (Pliskin et al., 1980). In contrast to approaches like HYE (health-years equivalents), DALY (disability-adjusted life years) or SAVE (save-young-lives equivalents), the QALY approach is preferred by many healthcare economists (Drummond et al., 2005). However, the CUA, especially the generic approach for estimating patients' utility, is often criticized for aggregating the utility too much, which neglects other output factors (Schöffski and von der Schulenburg, 2007)

Summarizing, of commonly used health economic analyses, the CUA is – despite its more complex calculation – best suited for analyzing the coordination service because it uses a more generic outcome measure. This allows to capture different facets of the coordination service that comprises processes and ICT-structure components and affects the complete patient care pathway. In Table 5.2, differences of the three major health economic analysis methods are summarized. The CBA only uses monetary units to assess benefits of a treatment, whereas the CEA and the CUA allow more qualitative assessment. In contrast to the CUA, the CEA only allows the comparison of alternatives that use the same outcome measure. Since both, the CEA and the CUA do not use monetary measures, they are not ethically questionable like the CBA is. Depending on the literature, the CBA is either portrayed as inferior (Schöffski and von der Schulenburg, 2007) or as superior (Drummond et al., 2005) to the CEA and CUA. This depends on the assessment of the ethical perspective. If the ethical perspective is viewed as questionable, the CBA is inferior. If it is viewed as unquestionable, the CBA is superior due to its large area of application. For the work at hand, the CUE proved to be most feasible for a general analysis of the co-

Category	Cost-Benefit-Analysis (CBA)	Cost-Effectiveness-Analysis (CEA)	Cost-Utility-Analysis (CUA)
Outcome measure	monetary units	medical parameters	QALY
Input / output ratio	monetary unit / monetary units	monetary unit / single medical indicator	monetary unit / QALY
Comparison of different alternatives	directly possible	only conditionally possible	directly possible
Ethically questionable	yes	no	no

Table 5.2: Comparison of the common health economic analysis methods (cp. Drummond et al. (2005)).

ordination service. When calculating the return on investment of implementing the coordination service for a particular stakeholder, the CBA is legitimate.

5.3.2 Effectiveness

In Section 4.1.3 performance standards and stroke-specific attributes of the coordination service have been discussed. Thereby, metrics for healthcare service quality, particularly determinants for the two HSQ categories, i.e. healthcare delivery quality and patient health, have already been introduced and assessed. The research hypotheses that were introduced in Section 5.1 are based on these categories. For healthcare deliver quality, patient self-management competences (PSMC) and timely utilization of healthcare services (TUHS) were investigated more closely. For patient health, final outcome (FO) and intermediate outcome (IO) indicators were assessed.

The means to measure the healthcare delivery share of HSQ, i.e. PSMC and TUHS, have been thoroughly investigated. In the beginning of the service development – when the coordination service requirements were gathered as described in Section 4.1 – available indicators were discussed with domain experts with respect to measurability, feasibility, reliability, and validity⁴. For example, smoking cessation and medical compliance were excluded because of validity⁵. Moreover, several

⁴Because of missing commonly-used instruments to measure healthcare delivery quality, as described in Section 4.1.3 only available instruments for patient health were investigated with respect to measurability, feasibility, reliability, and validity before the field study started. The identified indicators for determinants of healthcare delivery quality, such as knowledge of outpatient services, treatment adherence, or secondary prevention, still had to be investigated in detail for the use case.

⁵Smoking is one of the highest risk factors for stroke and smoking cessation should therefore be one of the most important indicators for measuring successful secondary prevention. However, in the

indicators such as adaption to the house, the exact time of introduction to aids, or body mass index were excluded because of reliability issues⁶. The same standards have been applied to the patient health indicators. Especially, the different instruments for the intermediate indicators, i.e. the activities of daily living (ADL), the functional activity, and the health-related quality of life (HRQOL), have been assessed. Additionally, final outcome indicators were also assessed again during the study. Consequently, acquired data about the re-hospitalization was discarded because it was not measurable. In the follow-ups at T1 and T3, it was not possible to acquire consistent information about stroke-related re-hospitalizations⁷.

Healthcare delivery quality

In order to assess healthcare delivery quality, patient self-management competences and timely utilization of healthcare services are measured, i.e. patient-centered structure and process determinants in the HSN. Since adequate **information provision** on patient side, which has been proven to have a positive effect (Cameron et al., 2008; Crawley, 1996; Pound et al., 1999), cannot be measured objectively to a full extent (Nolte et al., 2010), patients were asked in person. In addition to information provision, the degree of the patient's **adherence** to prescribed therapy or indicated secondary prevention is one of the most important measure. If, for example, patients follow medical and non-medical prevention by taking their medicine regularly or controlling their blood pressure, repercussions of any chronic disease are mitigated (Bodenheimer, 2008). Therefore, the patients were questioned regarding their secondary prevention. After their hospital discharge, the patients were contacted three months and twelve months after the stroke incident at point in time T1 and T3. The flowchart of stroke manager field study is illustrated in Figure 5.4. The complete questionnaire is available in Appendix B.2. The stroke patients were questioned regarding their situation after they left hospital, their knowledge about the available outpatient services, how to avoid another stroke, their behavior regarding medical, and their non-medical secondary prevention. At T1, the patients were asked if they lacked information about financial support possibilities, general support services, or miscellaneous stroke-related issues if they stated that their situation after they left the hospital had changed. The questions were based on the German version of the satisfaction with stroke care (SASC) questionnaire designed

small study population, its validity was not given because of inherent patient characteristics that were not controlled for. Since smokers are addicts, more than simple information or reminders are necessary for them to quit.

⁶In practice, test-retest reliability of these indicators could not be achieved. The indicators could not be retrieved with reasonable effort in a way that all patients understood the same meaning.

⁷In practice, re-hospitalization turned out to be difficult to assess because patients either did not want to provide the data or provided unreliable data. For example, one patient omitted that he had been hospitalized due to a heart attack because it was in a different hospital. Another patient reported being hospitalized several times even though these "re-hospitalizations" were only ambulatory treatments.

by Nolte et al. (2010) and the patient self-management questionnaire carried out by Schlote et al. (2008). Furthermore, the adherence data of the study group was gathered in the stroke health book (SHB) because they used it regularly during their post-acute treatment. The available data was then compared with the self-reported data from the patients to verify the validity.

Regarding the timely utilization of healthcare services, the transition process from inpatient to outpatient treatment has often been recognized as the point of the patient care pathway at which the most problems occur (Bodenheimer, 2008). According to the indicators identified in the service development phase (see Section 4.1.3), the patients were questioned about their **provisioning with aids, their social service visits, and their outpatient service utilization after discharge**, i.e. at T1 (see Appendix B.2 for details). Furthermore, when the patients were discharged from the hospital, i.e. at T0, the start and end dates of the rehabilitation phase, if prescribed, were taken from the hospital information system, in order to assess the **idle time between the rehabilitation phases**.

Patient health

For stroke, the most important final outcome indicators are **mortality, re-occurrences, re-hospitalization, and the needed level of care**, which was argued in Section 4.1.3. These final patient outcome indicators were also acquired using questionnaires at T1 and T3. If the patient could not be contacted for the follow-up questionnaire, relatives were interviewed to determine if the patient had died. If the patient could be contacted, questions regarding re-hospitalizations, other stroke-related incidents, and the currently needed level of care were asked as specified in Appendix B.2.

For intermediate patient outcome proxies there are numerous instruments available, which have been presented in detail in Section 4.1.3. For activities of daily living (ADL) and functional abilities, the **Barthel-Index (BI)** and the **modified Rankin Scale (mRS)**, respectively, were identified as the most valid, reliable, and feasible indicators. Both indicators are based on individual questions concerning patients' activities of daily living and their functional abilities. Originally, answers to the questions are given by a person that sees the patient face-to-face (Mahoney and Barthel, 1965), but telephone or postal questionnaires are also found reliable (Gompertz et al., 1994; Heuschmann et al., 2005; Janssen et al., 2010). Therefore, answers to the questions that make up the BI and the mRS were gathered using the questionnaires at T1 and T3. In case of the instruments for self-reported health-related quality of life (HRQOL), the analysis provided in Section 4.1.3 did not bring forth one instrument that has striking advantages over the other. Nevertheless, the **EQ-5D** is better suited for economic analysis because it allows to transform health states

to a utility value that can be used to compute quality adjusted life years (QALY)⁸, which are applicable in cost-utility-analysis (Greiner et al., 2005). Due to its superiority regarding the economic analysis, the EQ-5D was used in the field study and patients were given the EQ-5D questionnaire at T1 and T3. The three item Likert scale EQ-5D was used instead of the five item EQ-5D because even though the five items allow to generate more detailed health states, the three item questionnaire is better validated. Additionally, another advantage of the EQ-5D is that the BI scores may be used as an approximation for the HRQOL in case of missing values (Van Exel et al., 2004). This is important for baseline measurements because at point of the stroke incident, gathering self-reported HRQOL values is not feasible.

5.3.3 Efficiency

In the health economic context, efficiency signifies the extent to which an intervention converts the input, such as funds, expertise, or time, economically into an output. According to the theoretical considerations provided in Chapter 2, for the study at hand output is defined as impact on healthcare service quality. An assessment of efficiency relates the intervention's results to its costs, ideally putting a monetary value on the results. Since this often involves ethical controversial assumptions such as quantification of different patient health states there are several forms of cost analysis, which have been assessed in Section 5.3.1 This cost-benefit-ratio is addressed by the two research hypotheses that target service efficiency (see Section 5.1). One states that the service is profitable from hospital perspective for a certain number of patients. The other one states that the service is profitable from societal perspective, i.e. more patient-centered view.

Depending on the perspective different analysis forms have to be employed. For example, for the hospital business case a cost-benefit-analysis (CBA) was used. For the patient-centered, a more general analysis, the cost-utility-analysis (CUA) was used. Even though the CUA is rather complex during the analysis, it allows comparing effects of different treatments because patients' responses can be transformed to a generic utility using the time trade off (TTO) approach. This allows calculating quality-adjusted life years (QALY), which are a generic effect measurement that allows comparable efficiency calculations. Both, TTO and QALY, are presented in further detail in the next paragraphs.

The **quality-adjusted life years (QALY)** approach is based on the assumption that patients' health comprises their health-related quality (QOL) of life and the duration of this health state (La and Lawlor, 1990). QALYs are calculated by multi-

⁸Section 5.3.3 describes in more detail how the coordination service's efficiency can be determined based on such a cost-utility-analysis.

plying QOL with the time spent in this state. The best possible QOL for patients is signified by 1 and the worst, i.e. death, is signified by 0. Thus, one year with full QOL equals one QALY, which is identical to two years with a QOL value of 0.5. QALYs allow to compare patient-centered output of one treatment to another. Figure 5.5 illustrates how QALYs are used to quantify the advantage of a new treatment over regular care. It shows the QALY calculation exemplarily for patients with and without a specific treatment. Patients that receive the treatment live for 9 years with $QOL = 0.75$ and patients that receive no treatment live 7 years with $QOL = 0.5$. The QALYs are simply the area under the curve: 6.75 for patients with treatment and 3.5 for patients without treatment.

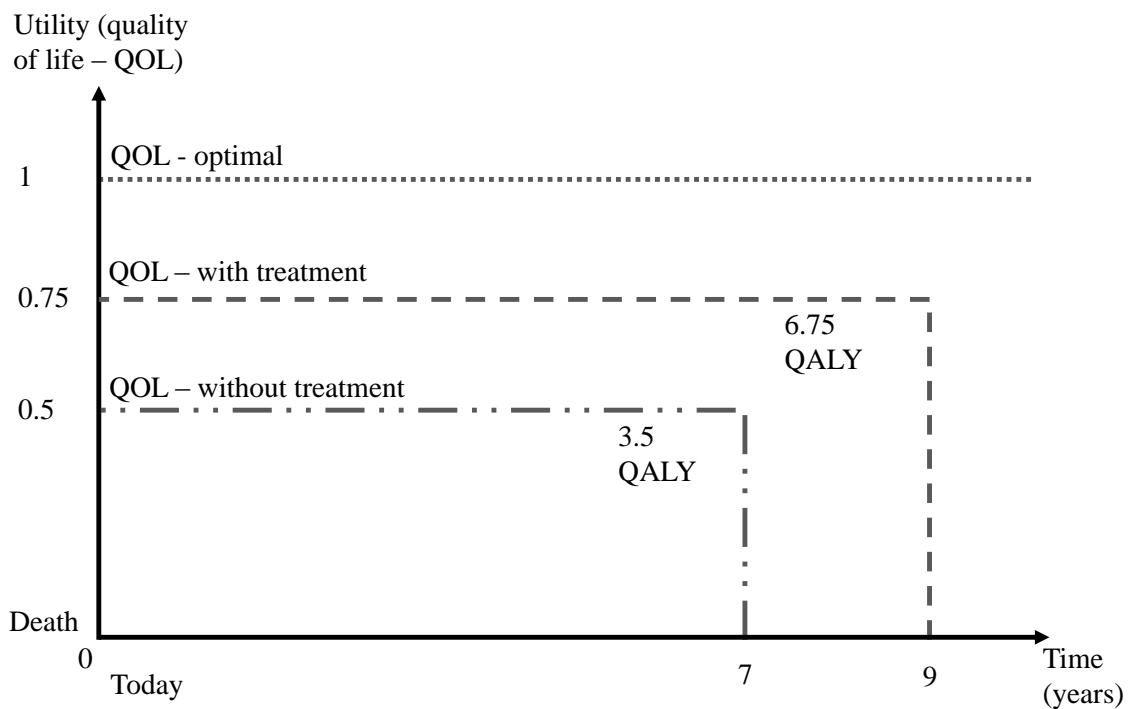


Figure 5.5: Calculation of quality-adjusted life years (QALY).

In practice, QALY calculation is based on multiple QOL values measured at different points in time to account for occurring changes over time (Schöffski and von der Schulenburg, 2007). For one treatment, QALYs are calculated for the individual time spans between measurement points and summed up to obtain the QALYs for the complete treatment. Even though the QALY concept provides a good opportunity to compare utility independent of medical parameters, it is viewed critically in the literature (Schöffski and von der Schulenburg, 2007). For example, it is arguable if ten years with a QOL of 0.1 – one QALY – are equal to only one year with optimal health, which is also one QALY (Bobinac et al., 2012). Furthermore, there are different, not necessarily comparable methods to obtain QOL values, on which the QALY calculation is based upon. Despite its controversial discussion, the QALY concept is a valid measure for patient's utility and was used in the work at hand.

The necessary QOL values were derived using the time trade off (TTO) approach, which has been validated for stroke patients by Haacke et al. (2006).

The **time trade off (TTO)** approach is based on the assumption that a human rationally prefers a shorter life with few or without any health-related issues over a longer life with serious health-related impairments (Greiner et al., 2005). The TTO is a tool that helps to determine the QOL of a patient or patient group. Its precise pattern is adapted to the current situation but always follows the following rule set (Schöffski and von der Schulenburg, 2007):

1. There is a health state i with a known duration until the point in time t . Usually, the health state i is one that goes along with severe health and the point in time t is death.
2. There is a known reference health state r which has a variable duration x with the condition $x < t$. The reference state r is assumed to be better than i and the point in time x is assumed to be premature death.
3. After establishing this setting, the patient is presented different time intervals $(0, x)$ in an appropriate way until the patient perceives the combination of (i, t) and (r, x) as equal.
4. For determining the QOL of the health state i , both combinations (i, t) and (r, x) are each multiplied, set equal and solved for i .

In Figure 5.6 the TTO calculation is shown exemplarily. The QOL of health state i for the duration of 15 years is investigated. For example, patients state that $QOL_r = 0.8$ for 10 years is equal to health state QOL_i for 15 years. These patient preferences have, for example, been acquired by means of face-to-face interviews with average patients.

In order to derive QOL_i from the given variables in the example illustrated in Figure 5.6, the following calculation is used exemplarily:

$$\begin{aligned}
 QOL_i * x_2 &= QOL_r * x_1 \\
 QOL_i * 15 &= 0.8 * 10 \\
 QOL_i &= \frac{0.8 * 10}{15} \\
 QOL_i &= 0.53
 \end{aligned}$$

In extreme cases, there are calculations that allow the QOL to drop below zero, which signifies that the person would rather be dead than in this health state (Drummond et al., 2005). However, these values are not considered in the work at hand because they are highly hypothetical and only arise during phases of very severe

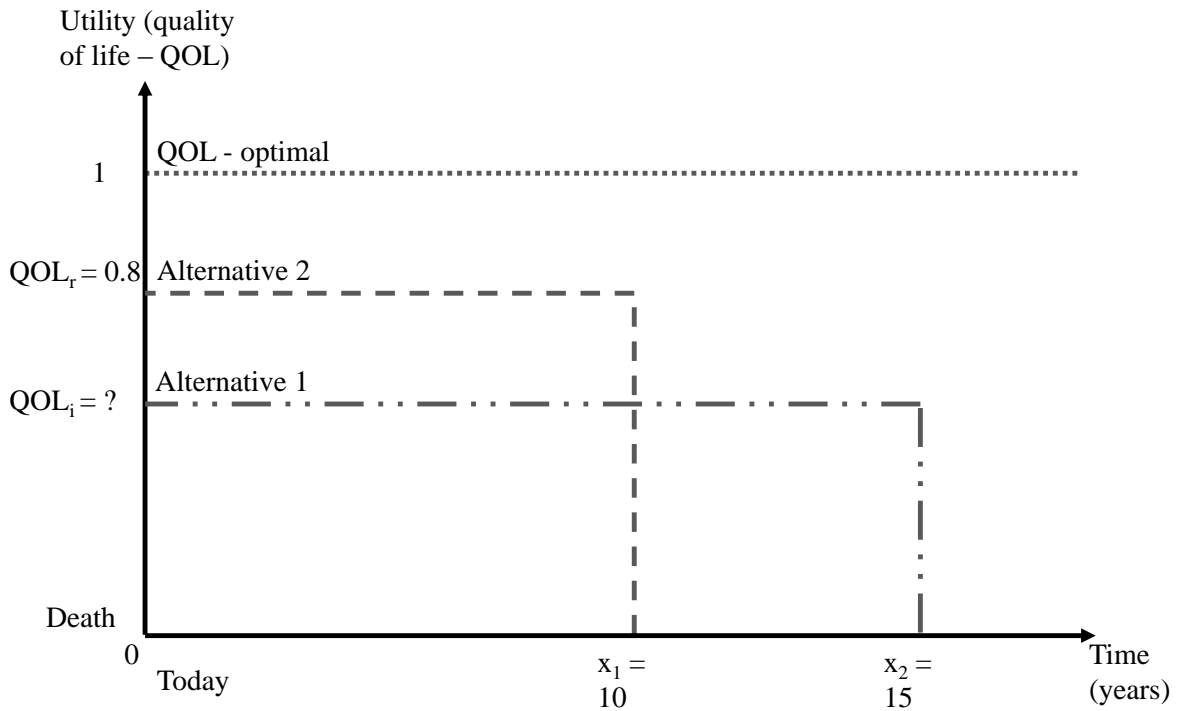


Figure 5.6: Calculation of the time trade off (TTO) value.

illness. Since the TTO approach requires much effort when determining the QOL of the individual health states, questionnaires have been developed and validated with the TTO tool. For example, answers from the EQ-5D questionnaire, which originally assesses HRQOL in the five dimensions mobility, self-care, usual activities, pain/discomfort, and anxiety/depression, can be transformed to QOL values (Greiner et al., 2005). Appendix B.4 describes in detail how the individual answers from the five dimensions are transformed to a single index value using an approximation formula with coefficients that weight each individual dimension. There are no general coefficients, because they are different for individual populations (Greiner et al., 2005).

5.3.4 Technology Adaption in Healthcare

Technology adaption and acceptance in healthcare information systems are critical issues, because they assess the user's tendencies to accept or reject the technology (Bhandari and Snowdon, 2011). There are no particular models that evaluate the technology adaption and acceptance of coordination services, but there are domain-independent models for evaluating the ICT-structure. One of the most prominent models is the technology acceptance model (TAM), which was first developed in 1985 and then published as a model for "perceived usefulness, perceived ease of use and user acceptance of information technology" in Davis (1989). The model assesses the users' attitude towards technology, which ultimately influences their intention

to use the technology. TAM has been modified several times to meet the diversity of the different user groups. Therefore, the subsequent TAM2 and TAM3 incorporate – among other moderating variables – gender and social situation.

The TAM and its two modifications, which still have the same major determinants, are based on the theory of reasoned action from the research field of social science (Davis, 1989). The model tries to capture the acceptance of people towards using information and communication technology. It is based on the assumption that the user's intention to use the ICT is influenced by the perceived ease of use and the perceived usefulness (Davis, 1989). This intention to use, i.e. the ICT acceptance, has a major impact on the actual usage of the technology. The model and its four major determinants are shown in Figure 5.7.

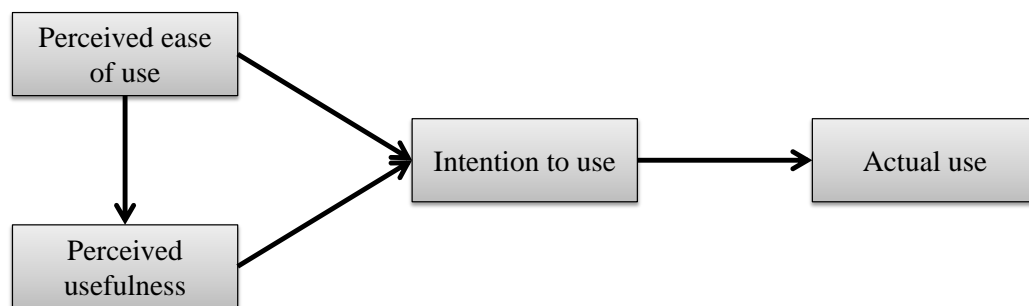


Figure 5.7: Technology acceptance model (TAM): major determinants and their influence as originally described by Davis (1989).

The most recent, prominent acceptance model is the unified theory of acceptance and use of technology (UTAUT) that has been described by (Venkatesh et al., 2003) as a synthesis of several, contemporary models. It incorporates the theory of reasoned action, the technology acceptance model, the theory of planned behavior, the model of PC utilization, the social cognitive theory, the innovation diffusion theory, the combined technology acceptance and planned behavior model, and the motivational model. The goal of the UTAUT is to create a holistic view on acceptance of ICT. As shown in Figure 5.8 performance expectancy, effort expectancy, social influence, and facilitating conditions are the major determinants that influence intention to use and subsequent actual use. The latter two are called behavioral intention and use behavior in the UTAUT, respectively. In this model the performance expectancy signifies the individual's perception that ICT will enhance task performance, and effort expectancy signifies individual's perception of the effort to use ICT. Social influence tries to capture the individual's perception of other people's opinion regarding the ICT usage. Facilitating conditions are miscellaneous conditions that can either obstruct or enable ICT usage. Furthermore, these four independent variables are moderated by gender, age, experience, and the voluntariness of use.

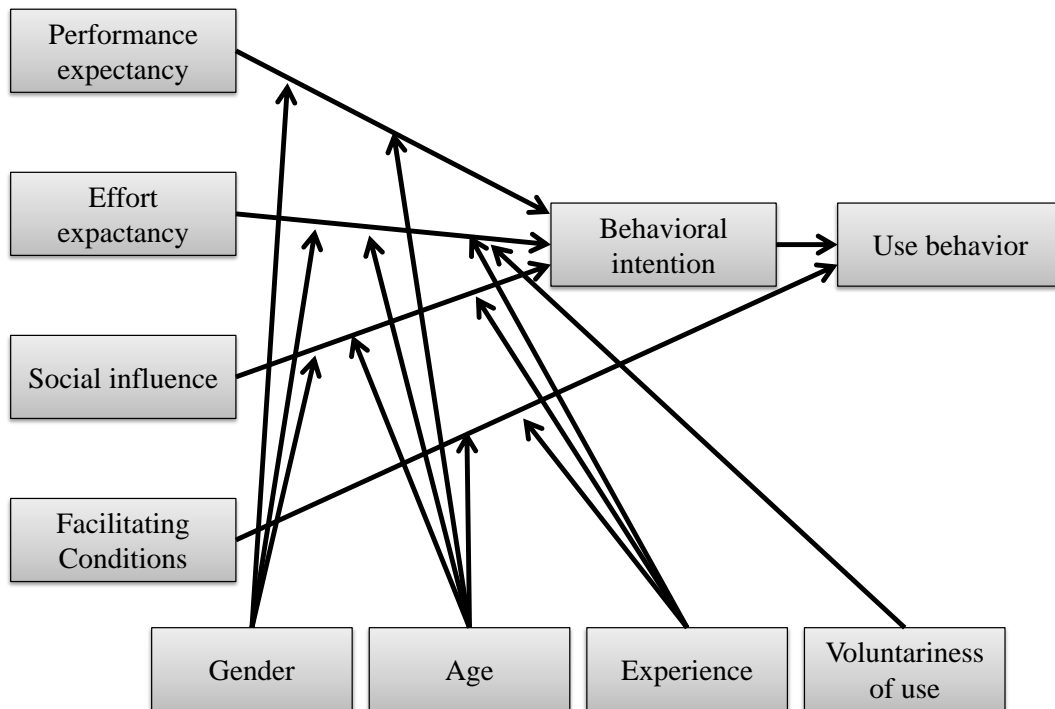


Figure 5.8: Unified theory of acceptance and use of technology (UTAUT): major determinants and their influence (cp. Venkatesh et al. (2003)).

TAM's simplicity is an advantage that makes it easy to understand and apply. It has been one of the most used models when investigating technology acceptance (Bagozzi, 2007). On the contrary, this simplicity makes it difficult for TAM to capture essential effects that are not covered by its main determinants (Bagozzi, 2007). For example, any kind of social influence can not be captured by TAM. UTAUT addresses these deficits by enhancing the model with context-specific variables. However, the large amount of independent variables makes the model very complex. Even though, Bagozzi (2007) show that UTAUT explained variance of 70% of intention to use in a setting in which TAM only explained 40%, Bagozzi (2007) also state that UTAUT is less frequently used than TAM. Additionally, even if UTAUT is used, often some moderating values are left out.

According to their original application area, the two major acceptance models – TAM and UTAUT – are not fit to be used for investigating acceptance of the coordination service as intended by the work at hand. Since ICT is rather a substantial part of the coordination service's processes, it can not be considered individually. ICT does not replace or support existing workflows but is an integral part of processes. In addition, service-related determinants and particular characteristics of stroke patients (see Section 4.1 for details) are covered by provided constructs. Therefore, based on the existing models an extended acceptance model had to be developed for the acceptance analysis. It is introduced in the following section.

5.3.5 Acceptance

When investigating the impact of the coordination service, its effects on healthcare service quality and the efficiency with which they are achieved are crucial. For evaluating the service holistically, assessing the coordination service's acceptance is also necessary. If a service is not accepted, it will not be used properly and, thus, will not have the anticipated effects (Tien and Goldschmidt-Clermont, 2009). On the one hand, overall satisfaction with the service has an impact on the acceptance (Parasuraman et al., 1988). In Section 2.1.2 several methods for capturing satisfaction as part of general service quality have been introduced. Even though, key service satisfaction concepts cannot be applied when looking at patient acceptance⁹, basic determinants can be used. On the other hand, service acceptance also depends on technology acceptance because ICT is an integral part of the coordination service.

Bhandari and Snowdon (2011) describe a strong relationship between TAM and service design. However, there is no study that describes the link between service design and technology acceptance determinants (Bhandari and Snowdon, 2011). Thus, a composite model was developed for patient acceptance in order to capture two parts: 1) technology and 2) service. First, the acceptance evaluation model is based on major models of technology acceptance, i.e. TAM and UTAUT (see Section 5.3.4). Second, key concepts of most prominent methods that aim at measuring customer satisfaction such as the GAP analysis (Parasuraman et al., 1985), SERVQUAL (Parasuraman et al., 1988), or KANO (Kano et al., 1984) are incorporated. Major determinants of the model are shown in Figure 5.9. The model is based on TAM and is extended by three moderating variables: Gender, age, and experience. Prior experience regarding the stroke-specific coordination service is clearly defined because patients have not used similar ICT before. It is therefore captured by items representing general technology experience.

In detail, particularly items regarding perceived usefulness and perceived ease of use were adapted to technology and service aspects. For example, empathy or professionalism of staff were asked, which is common for healthcare adaptations of customer satisfaction questionnaires (Parasuraman et al., 1988; Dagger and Sweeney, 2006). To address stroke-specific factors, questions were also partly based on the German version of the satisfaction with stroke care (SASC) questionnaire (Nolte et al., 2010). The complete questionnaire can be found in Appendix B.3. In contrast to the original 7-Likert scale TAM questions, the developed acceptance questions were adapted to a 5-Likert scale to match the SASC questionnaire and common practice in stroke questionnaires.

⁹In line with the argumentation in Section 2.1.2, patients' satisfaction cannot be the sole indicator because they cannot choose services freely.

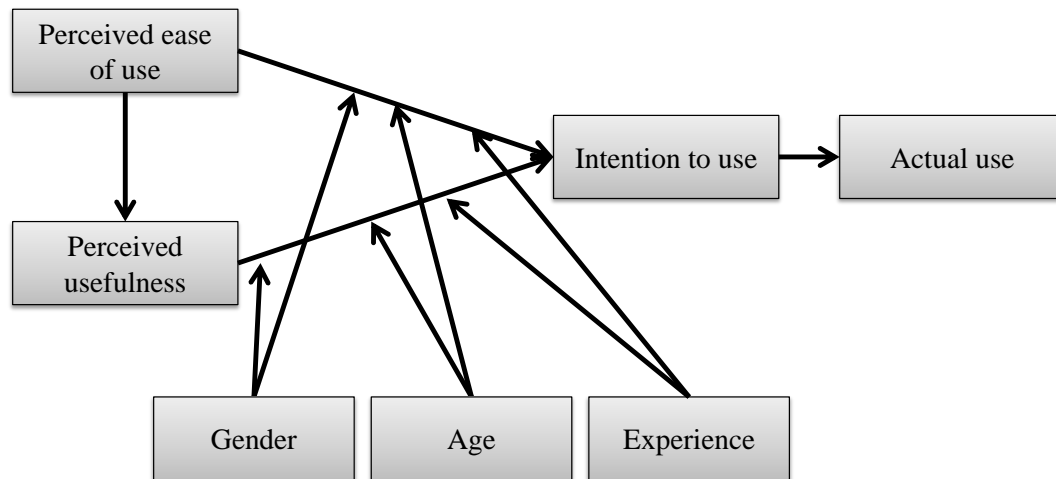


Figure 5.9: Acceptance model on which the acceptance evaluation is based upon.

Apart from patient acceptance, the healthcare service provider perspective was also taken into account. At T3, when patients were fully supported for 12 months after the stroke incident, involved providers were interviewed about their perceived usefulness of the coordination service. The data from the service providers was collected by means of in-depth semi-structured interviews. All interviews were audio-taped and transcribed verbatim.

5.3.6 Statistical Analysis

In order to compare the results of study and control group, bi-variate comparisons were performed to investigate the existing differences statistically as generally done in medical statistics (Armitage et al., 2008). All the indicators, which were investigated in the study, were compared using the most appropriate method for the type of variable to detect quantitative differences. If the indicators were investigated with respect to their differences in mean, t-tests were used for discrete normally distributed variables and Mann-Whitney-U test for non-normally distributed variables (Armitage et al., 2008). For the differences in discrete indicators, e.g. Likert scales, when difference in distribution was investigated, the Pearson Chi-Squared test was used (Armitage et al., 2008). In case of one degree of freedom, the Chi-Squared test was substituted by Fisher's exact test (Armitage et al., 2008). During the RCT development, the Kaplan-Meier estimator (Kaplan and Meier, 1958) was the destined estimator for survival rate because mortality is "right censored" data. According to Kaplan and Meier (1958), this "right censoring" particularly happens when observations are lost due to occurring events, e.g. premature death. However, the estimator was not used for the evaluation because there were too few data points with respect to patient mortality. As stated Section 5.1 in the course of the power analysis, a sig-

nificance level of 0.05 was used (Armitage et al., 2008) to determine if differences are statistically significant. In case of lacking knowledge about effect sizes or an anticipated high drop-out rate, Armitage et al. (2008) argue to introduce a borderline "not quite significant" level of 0.1.

Due to small sample size, results' missing statistical significance was expectable. Therefore, in addition to statistical analysis, the results were analyzed with a perspective on their combined occurrence and their robustness was tested using bootstrapping. The former was achieved by investigating the combined results of the different HSQ categories with a binomial test. This test calculates the probability of the combined tendencies for all indicators assuming that they are equal likely to occur if the investigated coordination service would not have any influence.

Bootstrapping is a resampling method for measuring and assessing statistical accuracy of a given data set (Efron and Tibshirani, 1986). It is most commonly used to verify results that are based on a small sample and when the sample's theoretical distribution is complex or entirely unknown. For example, when investigating coefficients' distribution of a logistic regression or simply when comparing the mean of two distributions that have unknown variances. Bootstrapping creates multiple samples from the original sample, which each have the same number of data points as the original. New samples are created by drawing repeatedly random elements from the original sample multiple times with replacement. The number of B bootstrapping samples of the original sample x_1, \dots, x_n are created as follows:

$$(5.5) \quad (x_{j1}^*, x_{j2}^*, \dots, x_{jn}^*), j = 1, \dots, B.$$

For each of these bootstrapping samples, usually at least 1000, statistical test such as the mean, median, or variance are calculated. Results are then consolidated, to provide an estimate for the original sample. For example, the standard error is estimated using an estimator $\hat{\Theta}$ for the underlying distribution of the original sample. Based on the values of the standard errors from the individual bootstrap samples $\hat{\Theta}^*(b)$, $b = 1, \dots, B$, the standard error $se(\hat{\Theta}) = \sqrt{VAR(\hat{\Theta})}$ is calculated as follows:

$$(5.6) \quad \hat{se}_B = \left\{ \frac{1}{B-1} \sum_{b=1}^B [\hat{\Theta}^*(b) - \hat{\Theta}^*(\cdot)]^2 \right\}^{1/2} \quad \text{with } \hat{\Theta}^*(\cdot) = \frac{1}{B} \sum_{b=1}^B \hat{\Theta}^*(b).$$

In case of a small sample, the results of the bootstrapping statistics are compared to the results of the statistics of the original sample to assess the robustness. In that sense, robustness means that the calculated statistical values of the original sample are robust with respect to outliers and, thus, significant, even though the underlying distribution is not known.

5.3.7 Summary & Pretest

In this section, the study methodology, i.e. the methods for data acquisition and data analysis have been introduced. The questionnaires and interview guidelines for T1/T3 and T2 can be found in Appendix B.2 and in Appendix B.3, respectively. Before the start of the study, all the questionnaires underwent a pretest. These pretests had the following effect on the data acquisition

- Comorbidity, i.e. other chronic diseases, is not included in the data. They were too difficult to ask and assess over the phone and using a written questionnaire.
- The questions about the patients' situation that were asked via the phone had to be completely revised. For example, many patients did not work before the stroke either. Therefore, the possible answers had to be enlarged. Similar issues arose concerning the question about necessary financial aids. If none were needed because the patient's situation had not changed significantly, the question was not answered correctly.
- Since questions about the nutrition were not quantifiable because they were too diverse, they were dropped from the questionnaire.
- According to Donabedian (1966) factors such as marital status, education, income, and occupation are not related to compliance. Since they were also perceived as intrusive during the pretests, they were not included in the questionnaires.

The final instruments that were used to acquire the data necessary to answer the Research Question 3 and the according hypotheses are shown in Table 5.3. The data was acquired at four different points in time during the stroke: T0) baseline after acute treatment, T1) three months after the patient's stroke incident, T2) three months after the patient's hospital discharge, and T3) twelve months after the patient's stroke incident. Which data was acquired at which point in time is shown in Table 5.3. Utility at T1 and T3 is not explicitly asked but transformed from the EQ-5D utility values.

5.4 Summary

In this Chapter, the evaluation methodology for the coordination service has been introduced. It essentially provides the methodology for answering Research Question 3. This research question deals with the impact of the coordination service

Hypotheses	Instruments	T0	T1	T2	T3
-	General data	x			
PSMS-1	Information provision about situation		x		
PSMS-2	Information provision about outpatient services		x		x
PSMS-3	Compliance regarding secondary prevention	x		x	
TUHS-1	Medical process data	x			
TUHS-2	Additional aids supply		x		
TUHS-3	Social service utilization		x		
TUHS-4	Outpatient service utilization		x		x
FO-1	Mortality		x		x
FO-2	level of care	x	x		x
FO-3	Re-occurrences		x		x
IO-1	BI	x	x		x
IO-2	mRS	x	x		x
IO-3	EQ-5D		x		x
CBR-1&2	Service costs				x
CBR-1	Hospital benefits				x
CBR-2	Patient utility	x	x		x
CA-1	Reported acceptance (Patient)			x	
CA-2	Reported Acceptance (Provider)				x

Table 5.3: Overview of the used indicators per data acquisition time (T0-T3).

and addresses its effectiveness, efficiency, and acceptance in the HSN. This chapter presented the study setting of this real-world application, whose basis is a randomized controlled trial in a case study approach. The RCT was designed to have two parallel groups: One study group that takes advantage of the stroke-specific coordination service and one control group that receives the "usual" care. Thus, the study group was part of an HSN, which provides central, patient-centered coordination, whereas the HSN of the control group received the "usual care," which is signified by provider-centered coordination. Since the study was designed to be single blind, the comparability of the results is ensured. In addition, to achieve identical patient cohorts, for patients to be eligible they had to abide by strict inclusion and exclusion criteria.

The RCT took place in a rural region in Germany with a large hospital as a hub that is specialized on neurological treatments. This ensured that most of the patients in the region were treated in the hospital where the study was located. The

objectives of the study were to evaluate the coordination service's effectiveness, efficiency, and acceptance. For all three categories, theses and specific hypotheses about the coordination service's effects have been postulated. The study itself took place from April 2012 until December 2013 but only the data acquired from July 2012 until December 2013 was evaluated. If included in the study, the stroke patients are observed for 12 months after their stroke incident with follow-up questionnaires three and 12 months after the stroke incident. Additionally, the patients from the study group get sent an additional questionnaire three months after the leave the inpatient treatment. Furthermore, the involved providers are interviewed after they have supported stroke patients from the control group for 12 months.

In Section 5.3 the particular study methodology was introduced in this chapter. In this section, fundamentals for health economic evaluation and technology acceptance have been introduced. Moreover, the specific instruments were presented that allow obtaining the indicators needed for the evaluation. For the effectiveness, the indicators were already gathered as performance standards during the coordination service development (see Section 4.1.3). However, valid and reliable instruments for efficiency and acceptance had to be assessed. Section 5.3 also presented the validation of the instruments for all three investigated parts of the impact, i.e. effectiveness, efficiency, and acceptance. In addition to describing the means of measurement, the means of analysis, e.g. statistical test, bootstrapping, or cost-utility-analyses, were also described.

One issue of the methodology is the missing multi-centered approach. The coordination service is only evaluated in one case study, which does not allow to control for case-specific abnormalities. In addition, since the coordination service can only be evaluated single blind, spill over effects can not be eliminated. The healthcare service providers essentially need to know which patients are supported by the stroke manager, which might have an impact on their behavior towards the other patients.

Regarding the evaluation methodology, the randomized controlled trial setup might pose difficulties. Even though the RCT as a field study allows investigating the effects in a real-world environment, it also induces a loss in control. When designing the study setting, different precautions were taken to ensure data validity, e.g. by similar patient cohorts. Nevertheless, such a real-world study is always prone to produce unanticipated effects that might decrease the results validity. The same applies to the power calculation made to determine how many patients should take part in the study. If, for example, the drop out rate is higher than anticipated or the effect size is not as large, the results might not be statistically significant. Overall, the RCT is nevertheless best available methodology to study the effects in a real-world environment.

Chapter 6

Service Evaluation Results

This chapter deals with the results of the field study, of which the methodology was presented in Chapter 5. It discusses the results related to Research Question 3 that investigates the impact of the coordination service in a real-world environment. The research question targets the service's effectiveness and efficiency regarding coordination in a healthcare service network as well as the acceptance of the involved stakeholders. In this chapter, the results of the field study are investigated with respect to the hypotheses that have been posed in Section 5.1.2. These hypotheses are investigated to draw conclusions regarding the three parts of Research Question 3. However, due to the small number of study patients, only the service's effectiveness evaluation is fully investigated with statistical means of analysis (see Section 5.3). Efficiency and acceptance evaluation were conducted with a small number of patients. Particularly the acceptance evaluation is therefore solely of descriptive nature. Nevertheless, all three parts provide insights about the coordination service's long-term impact in real world settings. In the following sections, the full-standing evaluation results of the coordination service are presented¹.

The first sections deals with the stroke-specific service's effectiveness and addresses the first sub question.

RQ 3.1 What is the coordination service's effectiveness?

In this section, the service's effects on the HSQ with respect to the HSN are described. It presents in detail, what kind of effect the coordination service has on the healthcare delivery quality and the patient health during the 12 months after the stroke incident. Subsequently, in the second section these effects are related to costs, i.e. input that was necessary to achieve the output, to investigate the coordination service's efficiency. This addresses the second sub question of Research Question 3.

¹For a small number of patients preliminary results of the effectiveness and efficiency evaluation have been presented at the AAL Kongress 2013 in Berlin, Germany (Görlitz et al., 2013).

RQ 3.2 What is the coordination service's efficiency from the different perspectives of the stakeholders in the HSN?

The third section presents the results of the inquiries regarding the involved stakeholder's acceptance. This addresses the third sub question, which investigates the acceptance of the involved stakeholders. It sheds some light on the service acceptance, e.g. the patients' acceptance of the used technologies such as an electronic blood pressure device.

RQ 3.3 Is the coordination service accepted by the stakeholders of the HSN?

The fourth section closes with a summary including the limitations and the implications of the presented results.

6.1 Demographic data

Stroke patients were recruited in the Neurological Clinic Bad Neustadt a.d. Saale (NBN) and followed up during the RCT from July 2012 until December 2013. Patients mainly originated from the rural area in northern Bavaria in Germany². The study population was mostly drawn from this region of approximately 518,000 inhabitants³. Based on German stroke incidence rates of 182/100.000 per year (Heuschmann et al., 2005), one should expect approximately 942 strokes per year in the region. The NBN treats 400 to 500 stroke patients from the investigated region every year. However, due to strict inclusion and exclusion criteria (see Section 5.1), not all of the possible stroke patients were eligible for the study. It took almost a year to recruit 108 patients, which the power calculation determined necessary to detect significant differences. Demographics of the study population are shown in Table 6.1 for all data acquisition points. Full data sets were obtained from 105 patients at T0, 65 patients at T1, and 21 patients at T3. At T2, when data was only obtained from the study group, 25 respondents provided full data sets.

The anticipated drop-out rate of 12.5% proved to be correct. It turned out to be even overestimated. Three study group patients already dropped out during the inpatient treatment phase. Two of them terminated their participation because of personal concerns after the first contact with the stroke manager and one died unforeseeable after being included in the study but before even talking to the stroke manager once. Five control group patients could not be reached for the follow-ups.

²The area consists of the administrative districts Rhön Grafeld, Bad Kissingen, Schweinfurt, Main Spessart, and Hassberge – see study context in Section 5.2.1 for more details.

³Bayrisches Landesamt für Statistik und Datenverarbeitung (BLSD): <http://www.statistikdaten.bayern.de>

		T0		T1		T2		T3	
		CG	SG	CG	SG	CG	SG	CG	SG
Number of patients		54	51	32	33	-	27	11	10
Gender	Male	28	30	16	18	-	17	7	8
	Female	26	21	16	15	-	10	4	2
Age	Average	70.92	65.21	71.03	70.23	-	64.67	69.23	65.20
	SD	10.35	12.67	09.67	11.93	-	12.04	10.84	08.34
	Median	73	67	73	67	-	64	73	66
	Max	88	86	88	86	-	86	88	76
	Min	44	46	52	46	-	46	53	49

Table 6.1: General demographics of the study patients (SG = study group, CG = control group, SD = standard deviation) at the different data acquisition points (T0, T1, T2, and T3).

However, as visible in Table 6.1, far less than the anticipated 94 patients⁴ provided data for the follow-up. This is mainly rooted in incomplete questionnaires, which was not expected during the study preparation. Many patients returned the questionnaires but did not completely fill them out. They omitted single questions or forgot to fill out whole pages. Since many of the indicators are based on multi-dimensional instruments, they were rendered useless if one or more of the items could not be given a precise value. Furthermore, due to the long period of patient recruitment, not all of the patients could be followed-up at T3 during the anticipated study period.

In spite of the small study population, both study and control group are similar regarding their characteristics: 1) None of the patients from either group had a certified level of care before the stroke incident, thus none were in need of professional care, not even partially; 2) All patients lived independently at home, mostly with their families; 3) They did not have any conditions that forced them to deal with many of the healthcare service providers in the HSN, and they did not have a stroke before; 4) In both groups, roughly one quarter of them still worked whereas the others were retired. Therefore, both groups had the same prerequisites with respect to coordination in an HSN and the major goal of the stroke-specific coordination service, i.e. improving the information flow. Furthermore, inclusion and exclusion criteria ensured that both groups were similar regarding stroke severity. Mean scores on Barthel-Index (CG: 93.87 and SG: 92.06) as well as on modified Rankin Scale (CG: 1.19 and SG: 1.32) were not significantly different (both p-values > 0.65). Only the

⁴According to the power calculation that was presented in Section 5.1.3, 47 patients are necessary for the study to provide significant results.

equal distribution of male and female could not be ensured. Albeit, the differences in gender distribution were not significant (p-values > 0.55 for T0, T1, and T3). Patients from the study group were on average a five years younger. Nevertheless, with the average age ranging from 64.67 to 71.03 these were no considerable differences (Heuschmann et al., 2010). In the following sections, the results regarding the impact of the coordination service are presented.

6.2 Coordination Service Effectiveness

In this section, the results regarding the stroke-specific coordination service effectiveness are presented, i.e. the effects on the HSQ of an HSN. Following the HSQ categories, this section has two subsections: *Healthcare delivery quality* and *patient health*. In the following paragraphs, the results of the respective indicators are analyzed and compared between the study group that took advantage of the coordination service and the control group that received the "usual care."

6.2.1 Healthcare Delivery Quality

The *healthcare delivery quality* comprises structure and process of HSQ, which was presented in Section 2.1.2. In Chapter 2 it was discussed that structure and process are too interdependent for the coordination in an HSN to be considered separately. In Chapter 4 the stroke-specific indicators for the HSQ categories were identified. Based on these findings, the patient self-management competences (information deficits after discharge, secondary prevention etc.) and the timely utilization and provision of healthcare services (transition process, social service consultation etc.) were identified.

Patient Self-management Competences (PSMC)

To assess the stroke-specific coordination service's effectiveness, the patient-self-management competences are investigated that relate to the information flow in the HSN. In Section 5.1.2 four research hypotheses were postulated regarding the patient self-management competences (PSMC). All four of them were statistically tested with the null hypothesis that there is no difference between study group and control group.

The first research hypothesis targets stroke patients' knowledge after leaving the inpatient setting. Patients were asked at T1, three months after the stroke incident, if their living conditions have had changed drastically compared to before their stroke incident. If so, they were further inquired about missing information with respect to financial aids, available services, or miscellaneous necessary information. Since pa-

tients whose living conditions did not require additional information would have distorted the evaluation results, they were not considered. Five patients from the control group and twelve from the study group self-assessed a drastic change in living conditions caused by the stroke. They all stated that they required more information than they were already given in the hospital. Table 6.2 shows results of the patient survey at T1 with respect to patient knowledge about their situation. Even though more patients from the study group reported a drastic change in their living conditions, significantly less reported missing information. Only regarding financial information, one patient from the study group reported missing information.

	Control group		Study group		p-value
Drastic change in living conditions	5	100.0%	12	100.0%	-
Missing information about finances	5	100.0%	1	8.3%	0.001
Missing information about services	3	60.0%	0	0.0%	0.014
Missing miscellaneous information	3	60.0%	0	0.0%	0.014

Table 6.2: Results patient knowledge: Number and percentage of patients missing information after discharge (multiple answers were possible) and the differences' significance tested with Fisher's exact test for each row.

Statistically significant difference between study group and control group were found applying a 2-tailed Fisher's exact test for each information category separately (see Table 6.2). Since the coordination service was developed and validated to provide individual information for stroke patients, more study group patients would have been provided with information if necessary. Thus, research hypothesis PSMC-1 stating that patients supported by the stroke manager have more knowledge about their situation after leaving inpatient settings was confirmed. Additionally, patients from both groups had a mild stroke that – judging by the collected inpatient data – had at least minor consequences in their daily life. However, a not quite significantly⁵ higher number of study group patients stated that their situation required additional information (p-value = 0.089, 2-tailed Fisher's exact test). This shows the influence of the stroke manager service on patient awareness with respect to their novel situation situation.

The second research hypothesis regarding patient self-management competences targets patient's knowledge about available outpatient services. By investigating patient's particular knowledge, results of the first hypothesis are undermined. This also shows the potential of the stroke-specific coordination service to decrease existing information deficits on the patient side. Patients were asked to

⁵Refer to Section 5.3 for the definitions of "not quite significant" in randomized controlled trials as described by Armitage et al. (2008).

check which services they know from a list of 16 outpatient services provided at T1 and T3, which is respective three months and twelve months after the stroke incident (see Appendix B.2 for details on the questionnaire). The accumulated number of patients for each number of outpatient services known are shown separately for control group and study group in Figure 6.1. On average, patients in the study group knew more services than the control group at T1 and T3. At T1, this difference is significant using a 2-tailed Mann-Whitney-U test for independent, ordinal data (p -value = 0.035). At T3, the 2-tailed p -value is 0.101, which – according to the statistical analysis fundamentals presented in Section 5.3 – is considered not to be statistically significant. The ex-ante power calculation estimated that 94 patients were necessary for statistically significant results⁶. Despite small sample size at T3 (data available from 21 patients), there is a large effect size of 4.1, which induces a large power for the differences at T3. Therefore, research hypothesis PSMC-2, which states that patients who are supported by the stroke manager know more outpatient supporting services, was also confirmed.

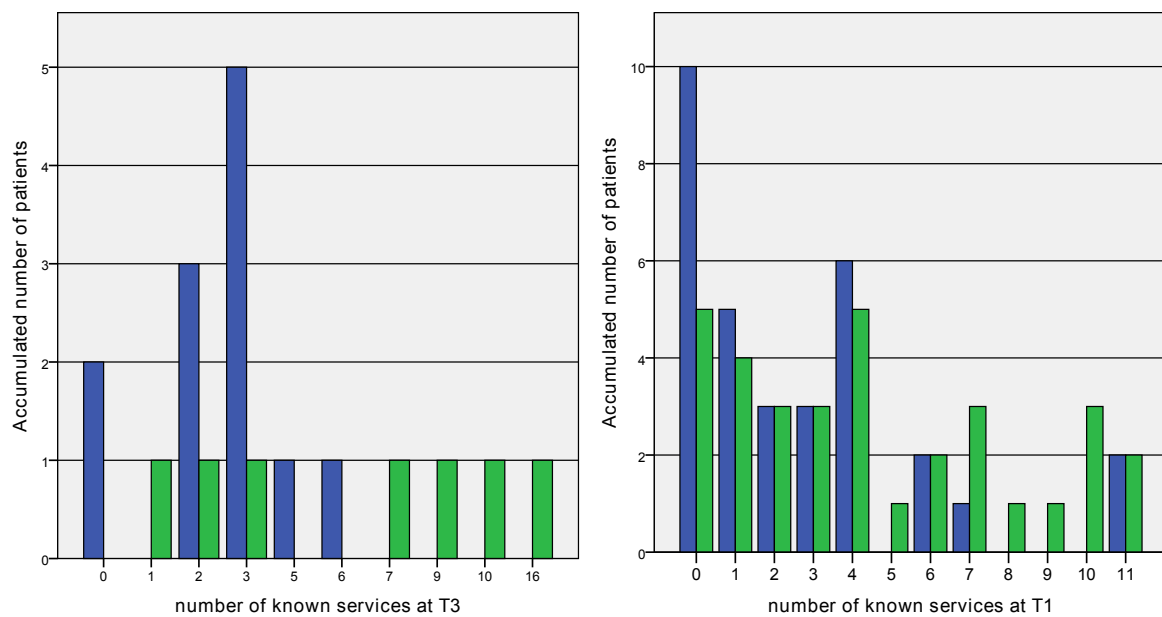


Figure 6.1: Results known services: Accumulated number of patients for the known number of available outpatient services at T1 (left) and T3 (right).

The third research hypothesis related to patient self-management competences deals with secondary prevention. The rationale behind this hypothesis is that information provision of the stroke-specific coordination service improves patients' knowledge and, thus, their behavior. Therefore, the patients were asked about their secondary prevention behavior at T1 and T3. Patients were asked how often they measure their blood pressure, perform physical activities, and drink alcohol. Results are shown in Figure 6.2, which illustrates that providing the information does

⁶As described in Section 5.3, .

not necessarily improve the patients' behavior. On the one hand, the patients from the study group appear to measure their blood pressure more often and they tend to drink alcohol less frequently. On the other hand, patients from the control group appear to be more physically active, at least at T1. Nevertheless, none of the differences between study group and control group proved to be statistically significant. Using the Pearson Chi-Squared test for the discrete, ordinal Likert scale data, no statistically significant difference between the two groups was found. Apart from measuring blood pressure at T1 with a p-value of 0.095, the p-values ranged from 0.470 (T3 measuring blood pressure) to 0.749 (T1 drinking alcohol). Hence, the research hypothesis PSMC-3 could not be confirmed because the underlying statistical hypotheses that there is no difference between both groups could not be rejected.

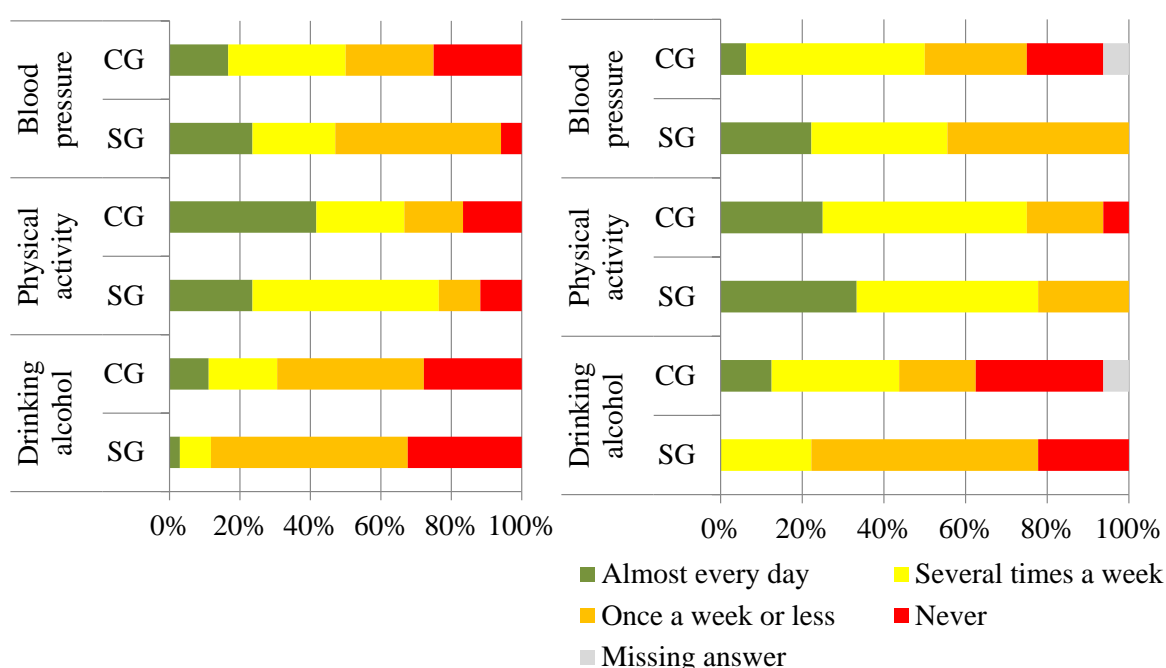


Figure 6.2: Results secondary prevention: Patients' performed secondary prevention at T1 (left) and T3 (right).

In summary, the first two research hypotheses, which investigate the service's impact on patients' self-management competences, are supported. The results show that, due to the information provision of the stroke manager, patients in the study group have better knowledge about available services. They also know better how to cope with the situation after a stroke. However, improved patient knowledge does not imply better secondary prevention.

Timely utilization of healthcare services (TUHS)

The timely utilization of healthcare services is crucial for assessing the HSQ in an HSN. In Section 5.1.2, four research hypotheses were postulated regarding the timely utilization of healthcare services as integral part of the *healthcare delivery qual-*

ity. The first one deals with the transition process phases whereas the other three hypotheses rather aim at structural parts of the *healthcare delivery quality*.

Research hypothesis TUHS-1 investigates the idle time between the different rehabilitation phases. According to Kjellström et al. (2007), often there is a delay between the end of one rehabilitation phase and the start of the subsequent one. None of the patients, neither control group nor study group, were in rehabilitation phase B because they all skipped that phase due to their rather good state of health. Therefore the days between the end of the acute stroke treatment and the start of rehabilitation phase C or – if phase C was omitted by the patients – the start of rehabilitation phase D was investigated. Furthermore, the days between the end of phase C and the beginning of phase D, if applicable, were also recorded. For a more detailed description of the rehabilitation phases refer to Section 3.3.4.

Results of mean idle days between rehabilitation phases are shown in Table 6.3. They are listed for each transition phase separately and all phases accumulated. As expected, most of the patients only needed rehabilitation in phase D. Thus, most transition times were recorded from phase A to phase D (31 control group patients and 25 study group patients). Apart from the idle time between phase C and D, mean idle times are higher for the control group. Particularly, idle times between phase A and C are much higher for the control group with 3.16 days than for the study group with only 1.96 days. However, the differences of the mean idle times were not statistically significant when using a t-test. Hence, research hypothesis TUHS-1 is not supported.

	Control group mean \pm SD	Study group mean \pm SD	p-value
Transition time A - C in days	0.86 \pm 2.26	0.00 \pm 0.00	0.354
Transition time A - D in days	3.16 \pm 3.69	1.96 \pm 3.44	0.219
Transition time C - D in days	0.00 \pm 0.00	0.00 \pm 0.00	n.a.*
Transition time (all) in days	2.36 \pm 3.43	1.53 \pm 3.08	0.267

Table 6.3: Results transition processes: Mean idle time between rehabilitation phases in days and the difference's significance tested with a t-test (* no t-test calculation possible due to nonexistant standard deviation).

In addition to process times of different rehabilitation phases, utilized services and available support, i.e. additional aids such as wheelchairs, were investigated. Research hypotheses TUHS-2 and TUHS-3 target utilization of healthcare services during transition phase. This has been proven to be important in stroke rehabilitation (Hensler et al., 2007; Cameron et al., 2008). Particularly, individual information about available aids and social service consultations during transition time have been proven to be effective (Crawley, 1996). Therefore, the patients were asked at

	Control group		Study group		p-value
Available additional aids data	46	100.0%	43	100.0%	-
Used additional aids	9	19.6%	7	16.2%	0.791
Available social service data	44	100.0%	44	100.0%	-
Used social service consultation	12	27.2%	18	40.9%	0.260

Table 6.4: Results transition support: Number and percentage of patients using transition services and the difference's significance tested with Fisher's exact test.

T1 what additional aids they have and if they visited the social service. Data about the necessity was drawn from the hospital information system during the inpatient treatment. Table 6.4 exhibits the differences between study group and control group with respect to additional aids and social service consultation. Overall, few patients from both groups took advantage of additional aids. This is not surprising because few patients were expected to qualify for additional aids based on the inclusion and exclusion criteria that favor patients suffering from a rather mild stroke. In contrast, all patients qualify for social service consultations. In fact, the German stroke guidelines aim at more than 75% of the stroke patients to visit the social service (Hensler et al., 2007). Compared to this goal of 75%, overall few patients have taken advantage of the social service consultations. Study group patients consulted the social service more often. However, differences for both indicators used additional aids and social service consultations are not statistically significant. Consequently, research hypotheses TUHS-2 and TUHS-3 are not supported.

Apart from used additional aids and social service consultations, used outpatient healthcare services were investigated. These outpatient healthcare services range from attending self-support groups to using different types of vocational training. The rationale behind the research hypothesis TUHS-4 is that, generally, stroke patients do not have enough information about available services and, thus, do not use rehabilitation services adequately (Cameron et al., 2008). Therefore, patients were questioned at T1 and T3 which outpatient services they take advantage off at the moment. As shown in Figure 6.3, more patients from the study group utilize outpatient healthcare services than the control group at T1. Using the Mann-Whitney-U test for independent, ordinal data, differences between control group and study group were shown to be not quite significant at the 5% level⁷ for T1 with a 2-tailed p-value of 0.081. At T3, differences in service utilization were not visibly striking. Even though less study group patients used no outpatient services at all, two control group patients used two outpatient services whereas none of the study group patients used more than one. The Mann-Whitney-U test yielded a p-value of 0.810 showing no

⁷Not quite significant was defined as $p < 0.1$ according to Armitage et al. (2008)

significant difference. On average, patients from the control group used more outpatient services than the study group. However, results at T3 are biased because the patients were asked what services they use at the moment and not what services they have used. Thus, patients that have severe health problems naturally use more outpatient healthcare services than healthy patients. When looking at results in more detail, this bias was proven. Study group patients predominantly stated to use additional services, such as attending self-support groups, whereas control group patients were participating in prescribed vocational training.

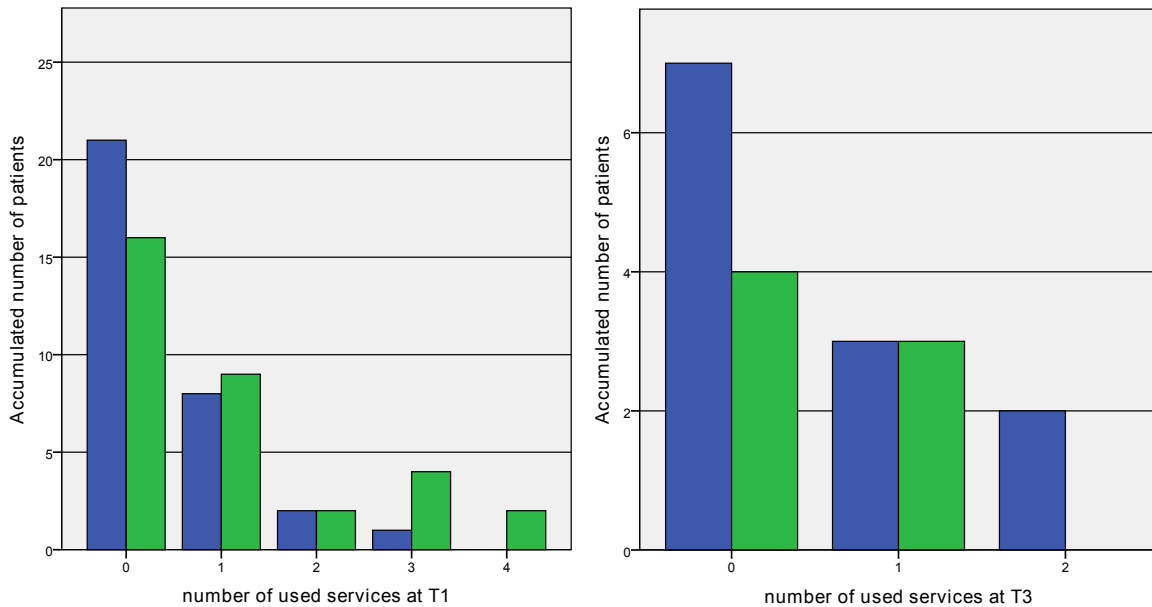


Figure 6.3: Results used services: Accumulated number of patients for the used number of available outpatient services at T1 (left) and T3 (right).

Because of the not quite significant differences in outpatient service usage at T1 and the ascertained result bias at T3, research hypothesis TUHS-4 partially supported. It states that patients supported by the stroke manager use more outpatient supporting services. In summary, the data about the timely utilization of healthcare services shows that the study group utilized healthcare services more extensively. However, except for the utilization of outpatient services at T1, there was no statistically significant difference. Nevertheless, for all investigated determinants – even if not statistically significant – there was either a tendency towards more utilization or they were equally used.

6.2.2 Patient Health

After investigating the stroke manager's impact on *healthcare delivery quality* as one major part of HSQ in an HSN in the previous subsection, in this subsection *patient*

health is investigated in more detail. In the following paragraphs, the patient outcome parameters are analyzed. They were discussed in Section 2.1.2 and have subsequently been further elaborated in Section 4.1. The parameters can be distinguished into final and intermediate outcome indicators for *patient health*. They specific indicators that have been used in the randomized controlled trial, have been introduced in Section 5.3. The six research hypotheses FO-1 to FO-3 and IO-1 to IO-3 target differences between study group and control group regarding these specific indicators.

Final outcome (FO)

Research hypotheses FO-1, FO-2, and FO-3 state that patients supported by the stroke manager have lower rates of mortality, care needed, and stroke re-occurrences, respectively. The final patient outcome indicators could only be evaluated conditionally because of two reasons. First, the patients were observed in a randomized controlled trial with a 12-months observation period. Since final indicators measure long-term effects, the observation period was already expected to be too short to detect significant differences. Second, due to the inclusion and exclusion criteria, the study population consisted of patients that were affected by rather mild strokes and, hence, had mild repercussions. Thus, rates of mortality, levels of professional care needed by patients, and rates of re-occurrences were not expected to be significantly different during the observation period. Albeit, the stroke-specific coordination service was designed to improve the information flow in the HSN, which affects the quality of post-acute rehabilitation. Therefore, next to the intermediate outcome the final outcome indicators were also assessed based on the three research hypotheses FO-1, FO-2, and FO-3.

Table 6.5 shows the final outcome indicators for both study group and control group. Numbers regarding mortality, level of care needed, and stroke re-occurrences were accumulated over time for all patients individually, i.e. if one patient needed professional care at T1, this patient was not counted again when still in need of professional care at T3. They are based on data that was collected at T1, T2, and T3. If data was available at multiple times, the most recent status was used. For example, one patient reported at T1 and at T3 that another stroke occurred. Stroke re-occurrences and the level of constant professional care⁸ needed, were reported by the patients themselves at T1 and T3. Since mortality rates could not be reported by the patients, the stated numbers have to be used cautiously. They were not confirmed officially but if patients could not be contacted because phones were de-registered and the sent out letters were returned unopened, they were assumed to be deceased. Furthermore, due to the few observations with respect to mortal-

⁸In Germany, there are three official levels of care "Pflegestufe 1-3," which have been used as reference and recorded at T1 and T3. Since the patients from the study group suffered from rather mild strokes, only "Pflegestufe 1" was reported if professional care was needed.

	Control group		Study group		p-value
Available data	32	100.0%	33	100.0%	-
Mortality*	3	9.4%	0	0.0%	0.25
Professional care needed	4	12.5%	2	6.0%	0.15
Stroke re-occurrences	1	3.1%	0	0.0%	0.69

Table 6.5: Results final outcome: Number and percentage of study patients' final outcome indicators and significance tested with Fisher's exact test (* unverified).

ity, the Kaplan-Meier estimator (Kaplan and Meier, 1958) could not be applied as intended.

Results regarding the final indicators show – as expected – no significant difference between study group and control group. As shown in Table 6.5, none of the three research hypotheses is statistically supported even though there are tendencies that the study group has less deceased patients, their level of needed care is lower, and they have lower reported stroke re-occurrences. Particularly, it is likely that three patients from the control group have deceased because of another stroke re-occurrence. Furthermore, they were likely to have needed professional care. However, since none of the data, including their correct health status, could be verified, only the known level of needed care and stroke re-occurrences were used during the evaluation. Based on this data, the differences between study group and control group regarding the final patient outcome indicators were statistically insignificant. Therefore, all three research hypotheses FO-1 to FO-3 were not supported by the data collected during the field study.

Intermediate outcome (IO)

In absence of reliable or significant final health outcome indicators, intermediate outcome indicators are used to assess the patient health at a given point of time. As described in Section 4.1.3, intermediate outcome indicators are proxies for final outcome. Moreover, Section 4.1.3 gave an understanding of relevant intermediate indicators: 1) patients' activities of daily living (ADL), 2) their functional abilities, and 3) their health related quality of life (HRQOL). Therefore, research hypotheses IO-1 to IO-3 target these indicators and state that the stroke manager improves each of these indicators.

The indicators ADL, functional abilities, and HRQOL have been measured using the Barthel-Index (BI), the modified Rankin Scale (mRS), the EuroQol 5-Dimensions questionnaire (EQ-5D), respectively. The BI approximates the ADL on a scale from 0 to 100, which equal complete dependance on professional help and having full physical capabilities, respectively. The mRS quantifies the disruption of the functional abilities using a scale ranging from 0 (full health) to 6 (death). The EQ-5D

consists of the five dimensions mobility, self-care, usual activities, pain/ discomfort, and anxiety/ depression as well as the visual analogue scale (VAS). As described by Greiner et al. (2005), values in the five dimensions can be transformed to a time trade off (TTO) value that approximates the HRQOL.

Data for the medical scales have been acquired at three points in time over the study period: T0, T1, and T3⁹. Since the stroke-specific coordination service starts taking action after successful acute treatment, any differences between control group and study group at T0 cannot be attributed to the stroke manager intervention. Moreover, when assessing the effects, one needs to keep in mind that the active phase of the stroke manager was the first three months after hospital discharge. This is the time between T0 and T1. As described in Section 4.2.2, during this time, the stroke manager service actively supports stroke patients in the study group by facilitating the information flow in the healthcare service network, particularly decreasing information deficits on the patient side and fostering patient empowerment.

Differences between study group and control group regarding their ADLs are illustrated in Figure 6.4. BI Values are stated additionally in Table B.7 in Appendix B.5. The figure shows mean scores of both groups at all three points of measurement. The 95% confidence interval is marked for each bar to give some more detail about the data's distribution. Two striking facts are visible. First of all, even though the study group has had a slightly worse mean BI at baseline T0, their mean score was equal to the control group's at T1 and even better than the control group's at T3. Secondly, mean BI scores of the study group consistently increased over time whereas the scores of the control group decreased between T1 and T3 after increasing from T0 to T1.

In spite of the clearly visible trend, none of the differences shown in Figure 6.4 is statistically significant (T0: $p = 0.960$, T1: $p = 0.376$, and T3: $p = 0.179$). For statistical tests, the Mann-Whitney-U test was used. A t-test would not yield meaningful results because the data was not distributed normally. Since a BI score has a maximum value of 100 and patients were not affected by a severe stroke, most patients had a BI score of 100. Because of missing statistical significance, research hypothesis IO-1 is not support. Nevertheless, at T3 the difference of mean scores between the two groups was 9.4 points. Practically, almost 10 points difference on BI scores might be the difference between being fully independent and needing help to climb stairs.

In the same manner as the BI scores, the mRS scores of control group and study group are shown in Figure 6.5. Differences in scores signify differences in functional abilities. The best possible mRS score is 0 – no limitations in functional abilities. Following the mean BI scores, the pattern of mRS mean values at T0, T1, and T3 that

⁹Refer to Section 5.2.2 for more details about the study flow.

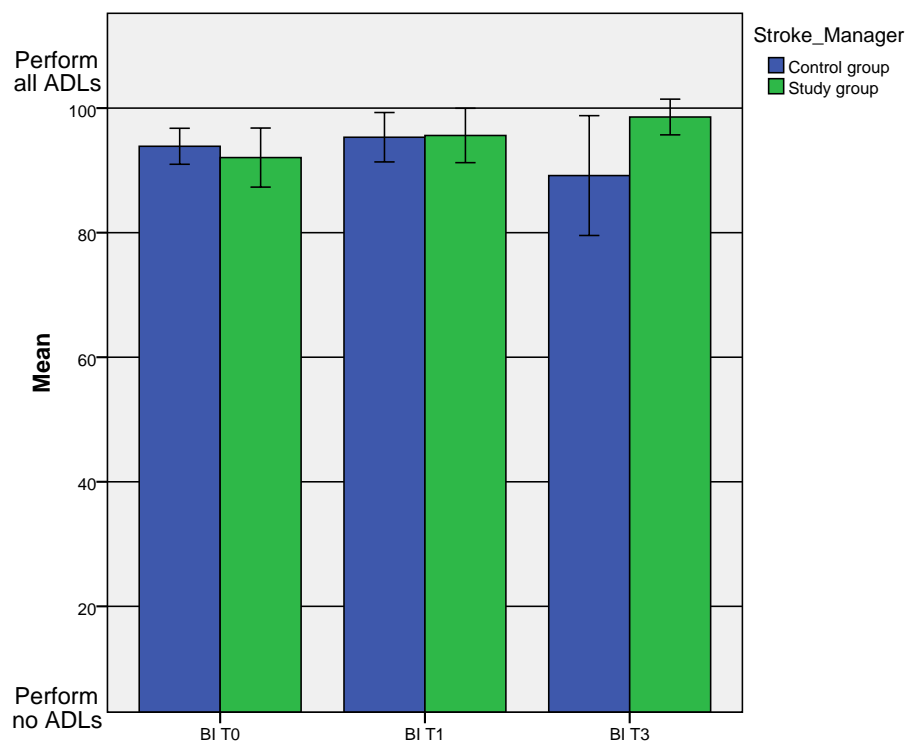


Figure 6.4: Results intermediate outcome: Rating of patients' possible activities of daily living measured with the Barthel-Index (BI) at T0, T1, and T3 (note: due to the BI scale's nature, the confidence intervals upper bounds are restricted by 100).

is shown in Figure 6.5 is similar to Figure 6.4. The mRS mean values for each group and point in time are stated in Table B.7 in Appendix B.5. Just like the mean BI scores, none of the visible differences in mean mRS scores is statistically significant using the Mann-Whitney-U test (T0: $p = 0.511$, T1: $p = 0.469$, and T3: $p = 0.108$). The Mann-Whitney-U test was used for the same reason as it was used for the BI scores: The data is not distributed normally because most patients had an mRS score of 0. Similar to research hypothesis IO-1, research hypothesis IO-2 is not supported because of missing statistical significance. In contrast, due to the difference at T3 that is not quite significant at the 5% level, IO-2 is borderline.

Figure 6.6 illustrates differences between control group and study group regarding patients' mean HRQOL at T0, T1, and T3, which is measured using the TTO value. Differences between the groups' mean scores are similar to differences of BI and mRS. Exact values are stated in Table B.7 in Appendix B.5. As for BI and mRS, the Mann-Whitney-U test was used for statistical analysis of differences in mean HRQOL scores. Due to the fact that the TTO scores at T0 are approximated using the BI, the p-value is the same. Similar to BI and mRS scores, there was no significant difference between mean values of HRQOL at T1 ($p = 0.960$) and at T1 ($p =$

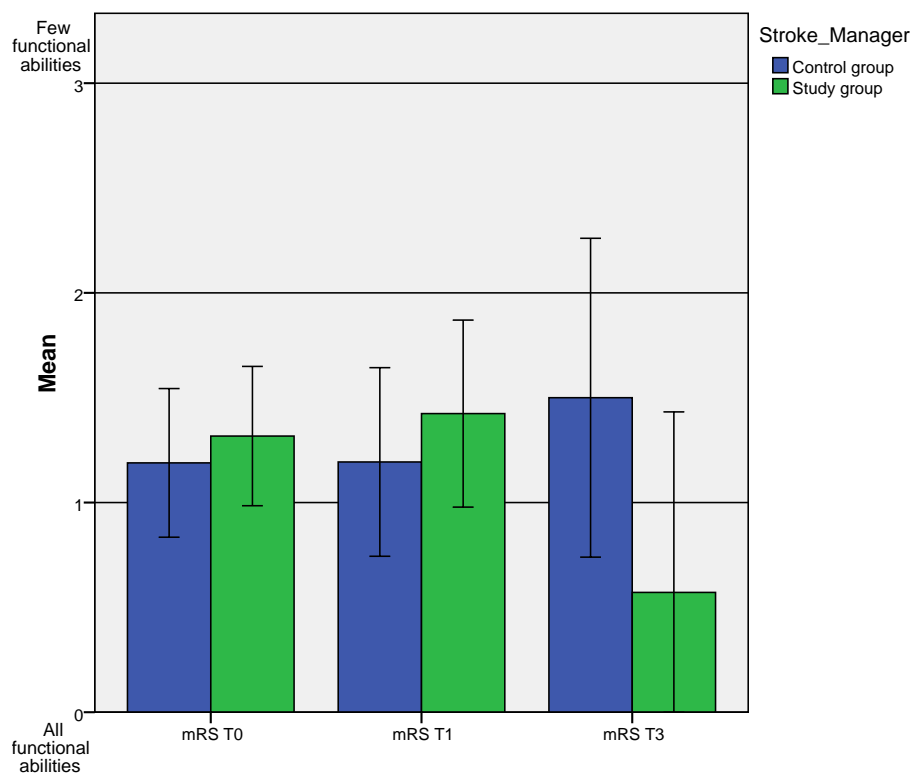


Figure 6.5: Results intermediate outcome: The patients' functional scores measured with the modified Rankin Scale (mRS) at T0, T1, and T3.

0.421). By contrast, there are significant differences ($p=0.042$) at T3, which support research hypothesis IO-3 stating that the stroke manager improves patient HRQOL.

In summary, only one of the six research hypotheses regarding patient outcome indicators was statistically supported. Since the number of study participants – particularly at T3 – was very low (see Table 6.1 in Section 6.1), most of the difference between the two study groups regarding intermediate outcome indicators were not statistically significant. Mean values were descriptively better for the study group. In order to endorse these descriptive differences between study group and control group, data has been bootstrapped (see Section 5.3 for details on how to use bootstrapping) to validate the robustness of differences in mean values. A 1000-times replication was used to bootstrap the scores of the BI, mRS, and TTO at T0, T1, and T3. Results are shown in Table B.7 in Appendix B.5. They show that the bootstrap values are robust with respect to mean scores and their standard deviation for all scores (BI, mRS, and TTO) at all measurement times (T0, T1, and T3). Especially, for the mRS at T0 and T1 the bootstrap decreases the standard deviation while maintaining the initial mean values. Therefore, research hypothesis IO-2 is not supported, yet borderline. In contrast, research hypothesis IO-3, which stud-

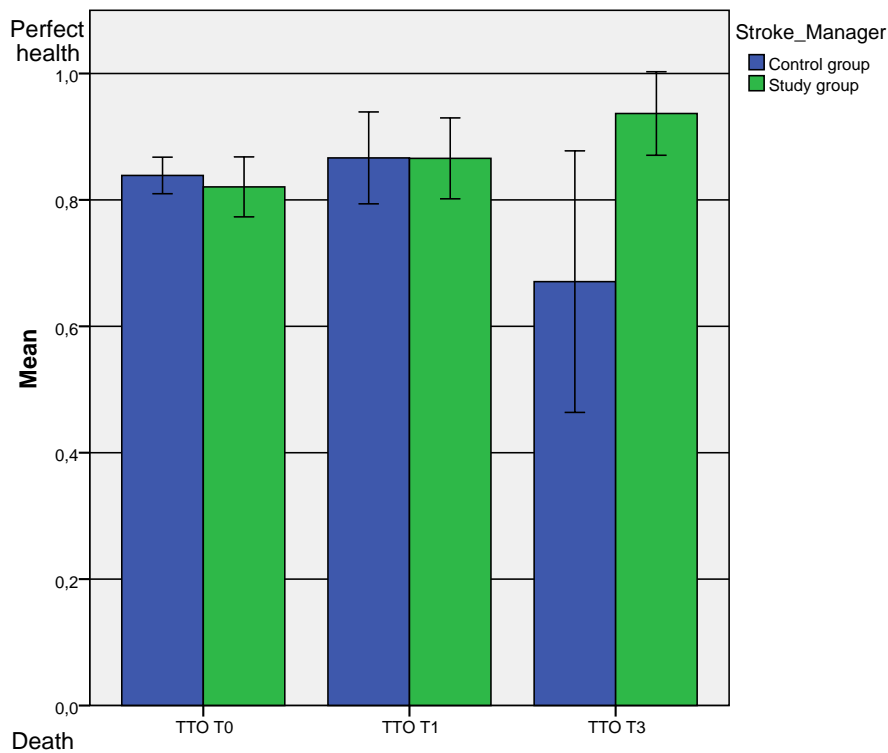


Figure 6.6: Results intermediate outcome: Patients' health-related quality of life approximated using the time trade off (TTO) value at T0, T1, and T3.

ies the influence on HRQOL, is fully supported by the original data as well as by bootstrap results.

6.2.3 Summary

In this section, the service's effectiveness evaluation has been presented. The evaluation consisted of analyzing the differences in HSQ between control group and study group. According to the methodology introduced in Section 5.3, the research hypotheses of the RCT were studied using the data acquired during the field study. The research hypotheses and the rationale behind them were presented in Section 5.1.2. They address the major determinants of HSQ from the two categories health-care delivery quality and patient health. Analysis showed that, among other determinants, particularly the patient self-management competences and the intermediate outcome determinants were positively influenced by the stroke-specific coordination service. In Table 6.6 a summary of all investigated research hypotheses is listed. The table shows whether the research hypotheses were supported by statistically and descriptive significant differences between study group and control group.

Metric	Hypotheses	Indicator	descriptive support	statistical support
Patient self-management competences	PSMC-1	Knowledge	✓	✓
	PSMC-2	Known services	✓	✓
	PSMC-3	Secondary prevention	–	–
Timely utilization of healthcare services	TUHS-1	Idle time	✓	–
	TUHS-2	Additional aids	–	–
	TUHS-3	Social service consult	✓	–
	TUHS-4	Used services	✓	(✓)
Final outcome	FO-1	Mortality	✓	–
	FO-2	Level of care	✓	–
	FO-3	Re-occurrences	✓	–
Intermediate outcome	IO-1	BI	✓	–
	IO-2	mRS	✓	(✓)
	IO-3	HRQOL	✓	✓

Table 6.6: Summary of research hypotheses used to evaluate the coordination service's effectiveness (significant support for hypothesis = ✓, borderline support for hypothesis = (✓), and no support for hypothesis = –).

In detail, the evaluation showed that patient self-management competences regarding patient knowledge were improved. Research hypotheses PSMC-1 and PSMC-2 were statistically supported by the evaluation. Thus, patients supported by the stroke manager have more knowledge about their situation after leaving the hospital. Patients from both groups had a mild stroke that – judging by the collected inpatient data – had at least minor consequences in their daily life. A significantly higher number of study group patients stated that their situation required additional information. This undermines the influence of the stroke manager service on patient awareness with respect to their novel situation. As described by Langhorne et al. (2011) the information provision to patients and their care-giving relatives is most important, but "the best way to provide the information is not known" (Langhorne et al., 2011). The developed coordination service is a feasible option for that. However, the evaluation also showed that providing the information does not necessarily improve the patients' behavior. Statistical Support for research hypothesis PSMC-3, which addressed the non-medical secondary prevention, was not found. Moreover, in contrast to the other indicators, it is not even descriptively supported because there were no tendencies visible that study group patients performed better secondary prevention.

Regarding the timely utilization of healthcare services, the evaluation showed no statistical significant difference between control group and study group. Neither was the idle time between the rehabilitation phases significantly reduced (TUHS-1) nor did the study group take significantly more advantage of the available services (TUHS-2 to TUHS-4) than the control group. Only for TUHS-4, which states that study group patients take advantage of more outpatient services, statistical support was borderline. The study group took advantage of not quite significantly more services at T1. Based on intermediate outcome results, it is save to say that the missing statistical significance at T3 is most likely caused by higher physical impairment of the control group at this point in time. This physical impairment demands them to take advantage of more outpatient services. Inspire of the missing statistical significance, results regarding timely utilization of healthcare services exhibited – apart from using additional aids – a clear descriptive support.

When looking at the patient health evaluation, final outcome indicators were mostly not stational significantly different whereas the intermediate outcome indicators were mostly significantly different. For final outcome indicators this was expected because, in general, the study population suffered from rather mild strokes. Therefore, none of the final outcome indicators was expected to be significantly different between study group and control group. However, descriptive support was shown by the completely independent indicators mortality (FO-1), care level (FO-2), and re-occurrences (FO-3). Furthermore, the three patients from the control group that could neither be confirmed dead nor be confirmed as simple study drop-outs were excluded from the evaluation of the final outcome indicators because of missing data. If they deceased, the chance is high that they had a stroke re-occurrence or needed a high level of care, which in turn would strengthen the postulated research hypothesis.

In contrast to the final outcome indicators, intermediate two of three indicators showed to be stational significantly different between study group and the control group. However, only at T3, which is twelve months after the stroke incident, both groups had significantly different scores on the medical scales, which measure functional abilities (IO-2) and HRQOL (IO-3). For functional abilities, which are measured using the mRS, the differences were on only borderline. As with the final outcome indicators, when including the three patients that supposedly deceased, the differences were significant.

Overall, 11 of the 13 investigated HSQ indicators are descriptively supporting the research hypotheses. In addition to the statistical analysis, results were analyzed with a perspective on their combined descriptive tendencies. Therefore, the probability of the observed results was calculated using the binomial test (see Section 5.3). Assuming that the coordination service has no effect, each of the investigated

HSQ indicators are likely to occur equally. According to the binomial test, having 11 "successes," i.e. clearly visible positive tendencies, in 13 "trials," i.e. the different indicators, has a 2-tailed p-value of 0.022. Even though not all differences of the individual indicators are statistically significant, the combined differences of the observed results are. Thus, results show that the coordination service has a significant effect on HSQ.

6.3 Coordination Service Efficiency

Once the effectiveness, i.e. the particular effects of the coordination service with respect to the HSQ in the HSN, has been investigated, the coordination service's efficiency can be analyzed. This means that the output, i.e. the impact, is related to the input necessary to achieve this output, i.e. the effort and costs. In doing so, this section deals with the second part of Research Question 3. Particularly, the two research hypotheses 5.1 and 5.2 (see Section 5.1.2) are investigated. They propose that the stroke-specific coordination service is profitable for a certain amount of patients supported by the stroke manager from a hospital perspective and from a societal perspective, respectively. As described in Section 2.1, there are different stakeholders in healthcare with conflicting interests. Therefore, efficiency considerations always have to be performed from a certain perspective.

In the following subsections, the coordination service's efficiency is analyzed from different perspectives using the methodology introduced in Section 5.3. First, necessary regular costs for maintaining the stroke-specific coordination service are determined. In the second subsection, an exemplary business case is presented for a hospital hosting the coordination service. In the third subsection, the results of the cost-benefit-analysis (CBA) from the hospital and the QALY-base cost-utility-analysis (CUA) are presented. The fourth subsection closes this section with a summary of the efficiency results.

6.3.1 Determining the Costs

Costs of any intervention are determined in three steps: 1) Identify directly and indirectly used resources, 2) determine measurable units of these resources that allow quantifying resource consumption, and 3) assess fix and variable costs of the consumed resource units (Drummond et al., 2005). For cost assessment, it is important to take the perspective into account. Especially, when assessing costs of consumed resources, different points of view – particularly of different stakeholders in the HSN and payers, i.e. mostly health insurances – have to be considered. Even among the

HSN stakeholders the perspective makes a difference. For example, costs for driving to a physician matter for patients but not for healthcare service providers. The same applies to any costs regarding disease prevention, which costs – depending on the situation – may be attributed to patient, to healthcare service provider, or even to society.

Since the stroke-specific coordination service is a service that is meant to be offered in addition to any existing treatments, it may be made available by any stakeholder in the healthcare system, and thus may be paid by either of them. Thus, it causes only direct costs for stakeholders that offer the service or contribute to it. In contrast, indirect costs, which might be incurred by other stakeholders or the society, are difficult to capture. Particularly, indirect long-term costs for healthcare service providers, for example caused by additional prevention screening, and indirect long-term costs for involved family and friends cannot be estimated reasonably. In addition, any indirect costs are highly debatable. Since it is inherent in the design of the service that it improves information flow and coordination, it encourages to utilize already budgeted services. In fact, it encourages expedient healthcare service utilization, which might even increase unnecessary service utilization. Either way, from the perspective of the service provider such indirect costs are insignificant. Thus, only direct costs, i.e. maintenance costs, are considered for the cost assessment. According to experience from the field study, maintenance costs of the stroke-specific coordination service can be divided into the following categories:

- **Staffing** is one of the most important but also most costly assets. Since the socio-technical service relies on individual and highly personalized processes, incorporating a person, i.e. the stroke manager, is crucial.
- **Software licenses** are considered for the maintenance of the CRM tool that allows efficient patient support.
- **Training** captures costs that occur during initial acquisition and implementation of the stroke-specific coordination service. Furthermore, there are training costs during the continuous operation that occur on a regular basis, e.g. update instructions.
- **Rent** includes the costs for leasing of the office. The person needs an office to work in and a quiet room to perform patient consultations.
- **Miscellaneous** costs include everything that comes up during the service's practices, such as providing hardware, telephone, electricity, and similar commodities.

Since development costs, which also qualify as direct costs, have been covered in a research project that developed the service, only maintenance costs are taken into

account. In Table 6.7 direct maintenance costs are summarized for each category based on the field study experience. They are reported per stroke manager and per year because this is – according to the hospital administration of the NBN – the most feasible unit for the hospital accounting. If necessary, the costs can be converted to Euro per patient. Moreover, they can be scaled up or down to different numbers of stroke managers because for simplicity all stated costs are matched to one stroke manager. For instance, rent is calculated for an $10m^2$ office that only one person could use. Hence, a second stroke manager would need another office this size. In practice, obviously economies of scale can be exploited. However, since the field study did not investigate how many persons could share one office without interfering their optimal workflow, possible economies of scale are not considered.

Category	Costs per stroke manager and year
Staffing	35,000 €
Software licenses	600 €
Training	800 €
Rent	1,800 €
Miscellaneous	2,000 €
Overall	40,200 €

Table 6.7: Direct costs of the stroke-specific coordination service for each category.

The personnel costs are based on an average salary of a management assistant in communication with a healthcare background. The position of a stroke manager does not require a nurse or somebody with a similar qualification. Nevertheless, a background in healthcare is necessary. The software licenses depend on the number of workstations. They are assumed to be 600 € based on licenses of CRM products that are specifically used for case management and allow the integration of telemedicine devices. Since the software was developed to be easy to use, the training of the stroke manager costs 800 €. The costs for rent amount to 1,800 €, which are based on the internal reference costs for an adequate office in the hospital of the study. Miscellaneous costs, such as costs for telephone usage or desk equipment, are deliberately estimated very high to account for the tablet costs and its depreciation over several years.

The resource consumption for maintaining the stroke-specific coordination service mainly depends on the number of patients that are taken care of. Furthermore, the number of patients a stroke manager can take care of and the hours a stroke manager can work have to be considered. The latter is approximately 1840 hours a year, which is determined by an average of 230 8-hours working days a year. These

average working days include vacation and absence due to illness. The number of patients that a stroke manager can take care of depends on the average time a stroke manager needs to support a patient for 12 months. Based on the empirical data from the field study in which the CRM tool logged the interaction time between patient and stroke manager, the average time the stroke manager spent with patient-related work was calculated to be 349 minutes, i.e. approximately six hours. In a semi-structured interview with the stroke manager, these six hours were exactly allocated to the acute treatment phase, the discharge phase, the active outpatient phase, and the passive outpatient phase as follows.

- During the inpatient treatment, the stroke manager assesses the patient's situation and provides individual information. On average this takes about 75 minutes per patient.
- For the transition phase, the stroke manager prepares the SHB for the patient and has one to four consultations with the patient and/or involved caregivers. On average this takes about 120 minutes per patient.
- During the active, outpatient phase right after discharge, patients need a varying amount of time depending on their situation. In general, during this phase, there are one or two consultations per month by phone. They add up to 90 minutes on average per patient.
- During the passive, outpatient phase the stroke manager does not contact the patients actively anymore. Furthermore, patients are often cared for sufficiently and do not contact the stroke manager either. Thus, even though it is the longest period in time, on average there are hardly more than one phone call every other months. On average, the stroke manager needs 75 minutes per patient.

In addition to these six hours of patient-related work, the stroke manager also stated in the interview that communication with inpatient and outpatient health-care services providers requires about two hours per patient. This time has not been recorded by the CRM tool and, therefore, has to be added to the six hours that the stroke manager needs for one stroke patient. In total, the stroke manager requires on average eight hours per patient for supporting them 12 months. Based on the 1840 hours per year, one stroke manager can support about 230 patients¹⁰. It costs 40,200.00 € to support 230 patients with the stroke-specific coordination ser-

¹⁰In this calculation, miscellaneous, overhead such as administrative work, training, or idle time, is neglected because it cannot be determined accurately. Thus, in practice, a stroke manager will most likely be able to take care of less than 230 patients effectively.

vice, which is 174.78€ per patient¹¹. Using these numbers, business cases for any stakeholder that qualifies as host for the coordination service can be calculated.

6.3.2 Hospital Business Case

Following the scenario that was applied during the field study, a business case is carried out for a neurological hospital as the host for the stroke-specific coordination service in an HSN. For this evaluation, the cost-benefit-analysis (CBA) is used because it provides a simple analysis method when only looking at return on investment of one stakeholder. It addresses the research hypothesis CBR-1, which states that the stroke manager service is profitable for the hospital. As described in Section 5.3.3, it is a method to generally describe the efficiency in monetary units based on a perspective. In this case, input, i.e. costs for the stroke-specific coordination service, are compared to output, i.e. monetary benefit for the hospital from the stroke-specific coordination service.

In order to conduct a CBA, the effects regarding HSQ in the HSN, which have been reported in Section 6.2, need to be transformed to monetary benefits for the hospital. This transformation is based on interviews that have been administered in the hospital with domain experts after the field study. In the interviews, hospital administration staff stated that the increase in HRQOL does not explicitly transform into a monetary benefit from a hospital perspective. However, they acknowledged that active patient management induces better process management and that better patient health provides reputation. Especially, the latter is viewed as an increasingly important factor because patients have more possibilities to choose the health-care service providers. Therefore, the benefits are rather intangible and can only be estimated using a lower and an upper bound. The identified benefits as well as their magnitude are shown in Table 6.8.

Category	Maximum benefits	Minimum benefits
Patients pay themselves	50 € per patient	0 € per patient
Additional patient revenue through reputation	1,000 € every 10 patients	1,000 € every 20 patients
Savings through less complications	50 € every 5 patients	50 € every 10 patients
Savings through less complaints	20 minutes of the staff's time per patient	5 minutes of the staff's time per patient

Table 6.8: Monetary benefits of the stroke-specific coordination service for each category.

¹¹Only stroke manager related costs are included. For example, long-term costs incurred by a higher service utilization of more-informed stroke patients are difficult to estimate and not considered.

First of all, patients that pay the hospital to use the service were identified as income source. Furthermore, increasing reputation was stated to have an impact on the overall profit of the hospital. Every stroke patient treated in the hospital generates approximately 1000 € revenue. It was estimated that every 10 to 20 patients that are supported by the stroke manager, an additional patient is treated in the hospital because of reputation gains. This does not necessarily have to be a different patient. Possibly, one of the treated patients decides to use the ambulatory services of the hospital. The hospital's benefits from the increase in medical process compliance and more informed patients were stated to have a monetary effect on the number of arising complications and the time patients occupy the hospital staff due to complaints or asked questions. These benefits transform into the following cost savings with respect to complaints and complications as well as saved time. On the one hand, there is a potential in saving approximately 50 € per omitted complication or complaint. It was estimated that every 5 to 10 patients, one arising complication can be resolved by the stroke manager. Every 10 patients (worst case) or every 5 patients (best case), one patient causes less complication that each save 50 € for the hospital. Additionally, every stroke manager patient was estimated to save 5 to 20 minutes for medical and administrative personnel.

The CBA based on the calculated costs and benefits from a hospital perspective is shown in Figure 6.7. It illustrates that costs and benefits increase with a linearly growing number of patients. According to the interviewed domain experts it is safe to assume that the stroke manager person does not have to work full time. For simplicity reasons, the CBA can therefore be conducted with linearly growing number of patients because the working hours are assumed to be dividable in an arbitrary fashion. Furthermore, it clearly shows that costs are between minimum and maximum profit which the stroke-specific coordination service might generate. Thus, it does not have a secure positive profit margin for the hospital.

Because of this ambiguous result, research hypothesis CBR-1 is not fully supported. Nevertheless, the hospital has two options that make implementing the coordination service worthwhile. First, the strategic value of implementing such a coordination concept can be priced into the profit calculation. Particularly, when facing more empowered patients, which are able to make more self-determined decisions, reputation becomes a growing intangible asset. Second, arising costs can be split between stakeholders of the HSN, e.g. other healthcare service providers, or partially be provided by the payers of healthcare services, e.g. insurance companies.

For this second option, hospitals can either form alliances with other stakeholders or sell the service to insurance companies. For example, ambulatory healthcare service providers also benefit from a service that supports patients along the complete patient care pathway, provides information about available outpatient ser-

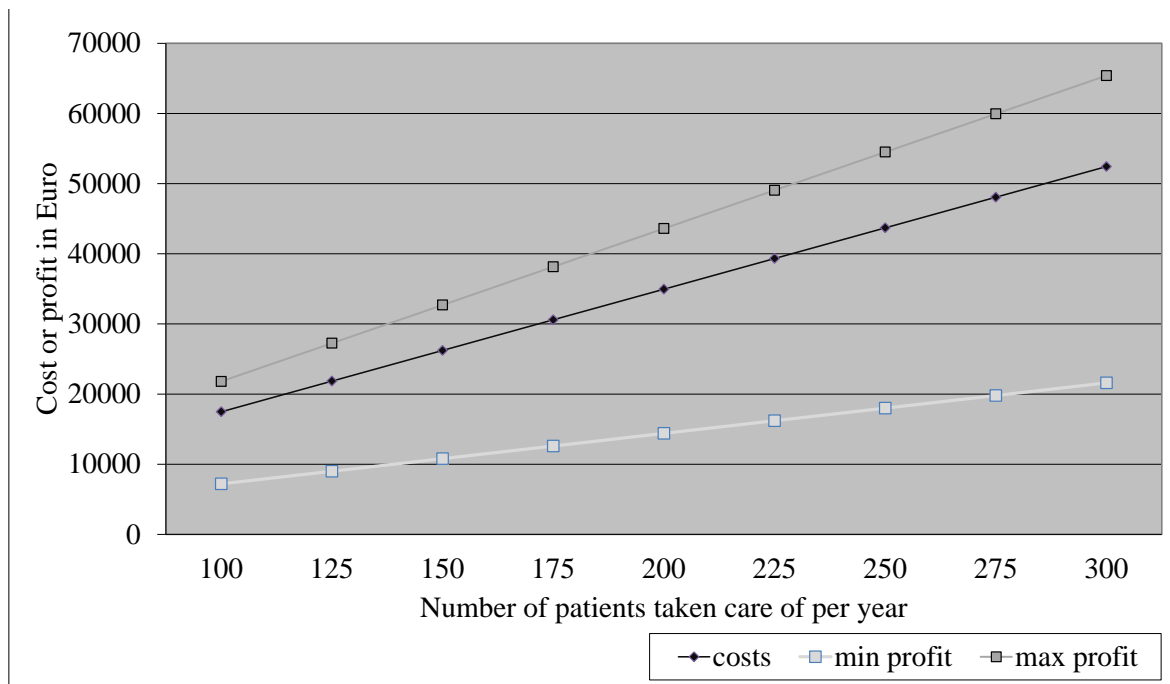


Figure 6.7: Cost-Benefit-Analysis (CBA) from the hospital perspective for the stroke-specific coordination service.

vices, and even helps patients to utilize available outpatient services. When taking this approach, the network is similar to integrated care, which was described in Section 3.3. Thus, contractual constraints are similar and might exclude certain healthcare service providers in the HSN. When tackling healthcare insurances, which are often payers of patients' healthcare services, the benefit must be proven. One way is to provide long-term results showing positive cost-benefit-ratios and the other is using QALYs, which serves as indicator for HRQOL. Based on the effectiveness results presented in Section 6.2, the long-term effects that are relevant for insurances, e.g. level of needed care or re-occurrences, were improved by the coordination service. However, the differences were not statistically significant. Therefore, the other option, using QALYs, is pursued in the next subsection. It provides a more general cost-utility-analysis.

6.3.3 Cost-Utility-Analysis

When taking the patient-centered perspective, it is ethically questionable if such an efficiency analysis can be performed by only using monetary units. Furthermore, in contrast to the business case presented in Section 6.3.2, benefits for patients are difficult to be determined directly. Different effects presented in Section 6.2, particularly, effects related to patient health are difficult to be compared among each other. For example, it is undefined if a BI score of 80 is better than an mRS score of 2 or

vice versa. Moreover, even if such a relationship existed, it is unclear whether living with any score for 2 years is better than living a lower score for 3 years.

In order to overcome these problems, the cost-utility-analysis (CUA) has been used in the work at hand. As described explicitly in Section 5.3, the CUA relates incurred costs to a generic outcome value such as quality-adjusted life years (QALY). Using QALYs, different patient outcome parameters can be compared and assessed using an aggregated utility measure. This allows to assess a health-related intervention, i.e. the stroke-specific coordination service, to be evaluated from a societal perspective as proposed by research hypothesis CBR-2.

Before this utility assessment could take place in the efficiency analysis, available outcome values had to be transformed in generic QALY measures. The transformation steps are shown in Figure 6.8. As prerequisites, the transformation required EQ-5D codes, i.e. concatenated values from the five different EQ-5D dimensions, and time trade off (TTO) preferences values of the study population. For the analysis, German preference values according to Greiner et al. (2005) were used.

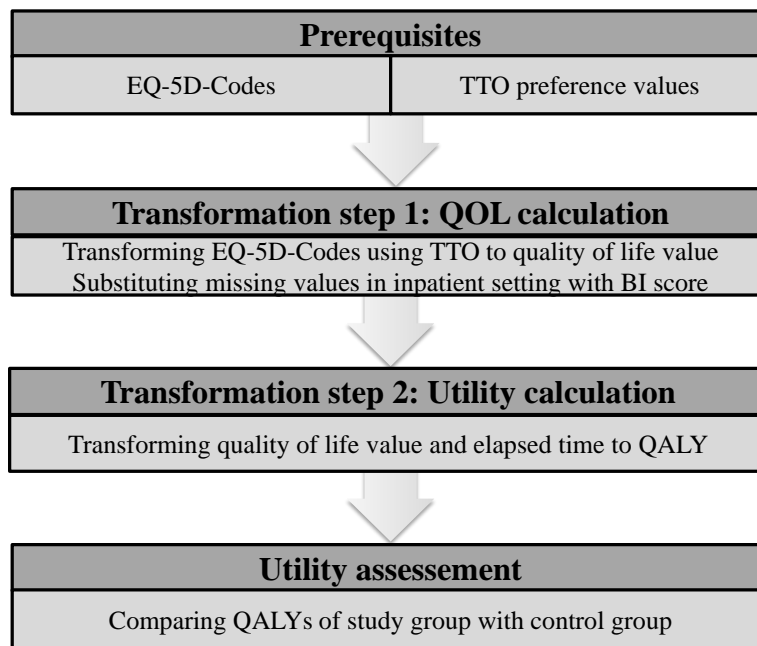


Figure 6.8: Transformation process for determining the utility.

The **first transformation** step involves calculating the quality of life (QOL) by using the following formula:

$$(6.1) \quad QOL = \alpha + \beta_1 MO + \beta_2 SC + \beta_3 UA + \beta_4 PD + \beta_5 AD + \beta_6 M2 + \beta_7 S2 + \beta_8 U2 + \beta_9 P2 + \beta_{10} A2 + \beta_{11} N3$$

In (6.1) the coefficients α and β_i signify population-based preference values. They have been identified by Greiner et al. (2005) using a regression analysis based on QOL values acquired using the TTO method and corresponding EQ-5D codes in a large German population. The variables in (6.1) MO to $N3$ are based on the individual values of the EQ-5D dimensions. For example, if a patient stated severe problems in mobility (MO) and mild pain/discomfort (PD) then $MO = 2$, $M2 = 1$, $PD = 1$, and $P2 = 0$. Appendix B.4 illustrates this variable allocation according to the EQ-5D values in more detail. The more additional QOL values are available during the study period, the more precise is the QALY calculation. In the field study, EQ-5D values were acquired at T1 and T3. At T0, during the acute treatment, no EQ-5D questionnaires were administered because of ethical issues. However, since the BI scores have proven to work as adequate approximation of the QOL during inpatient settings (Van Exel et al., 2004), they were used for the missing QOL values at T0.

The **second transformation step** consists of calculating the QALYs by multiplying the QOL with the elapsed time. One year at full QOL equals one QALY. The QALY calculation was described in detail in Section 5.3. Based on the three QOL values at T0, T1, and T3, the difference in QALYs with respect to the stroke incident at T0 was calculated for the study group and the control group. For both groups the gained/lost QALYs were calculated separately for the period [T0, T1] and [T1, T3].

During the **utility assessment**, the QALYs of the study group and the control group in the investigated time period were compared. As illustrated in Figure 6.9, the calculated difference between the gained/lost QALYs of study group and control group were investigated for the two periods separately. Since the values of both groups are the same at T1, it is clearly visible that the study group has a higher increase in QOL in the period [T0,T1] and a lower decrease in QOL in the period [T1,T3]. The gains and losses were therefore summed up as basic triangle areas using the following formula.

$$QALY_{diff} = 3 \frac{QOL_{SG}(T1) - QOL_{SG}(T0) - QOL_{CG}(T1) + QOL_{CG}(T0)}{2 * 12} + 9 \frac{QOL_{CG}(T1) - QOL_{CG}(T3) - QOL_{SG}(T1) + QOL_{SG}(T3)}{2 * 12}$$

Based on the mean BI values at T0, which have been normalized to [0,1], as well as the mean TTO values of the EQ-5D codes at T1 and T3, the stroke-specific coordination service utility was calculated. The exact values for both study group and control group have been reported in Section 6.2. The mean utility difference between the stroke-specific coordination service and the "usual care" was calculated to be 0.0022 QALYs for [T0,T1] and 0.0975 QALYs for [T1,T3]. Therefore, the calcu-

lated overall utility advantage of the stroke-specific coordination service was 0.0997 QALYs.

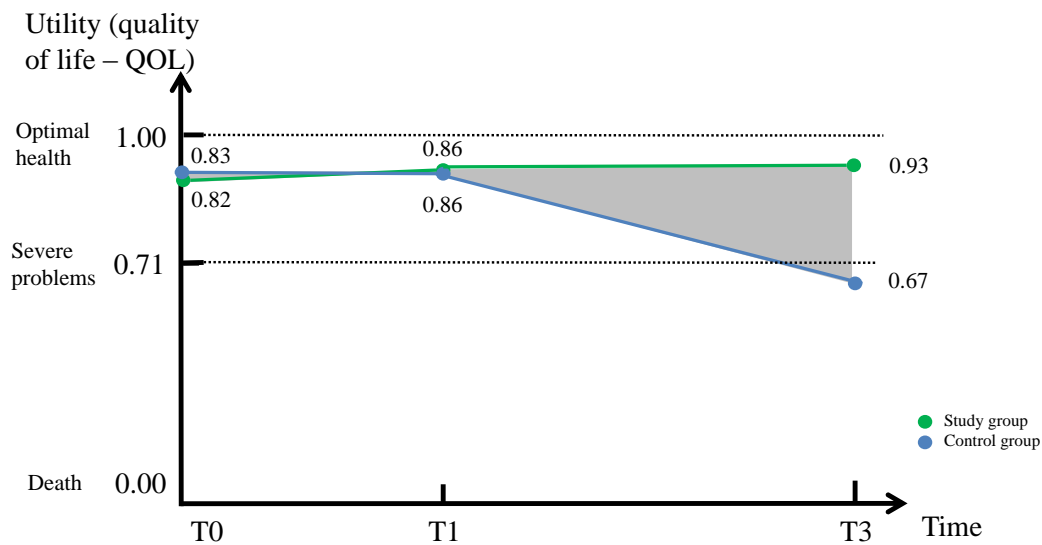


Figure 6.9: Difference in QALYs between study and control group.

Since the differences between the HRQOL values have not been proven to be significant¹², the 95% confidence intervals were transferred to the QALY calculation, in order to increase their expressiveness. The lower bound value was calculated by taking the lower bound value of the 95% confidence interval for the QOL values at T0, T1, and T3 for the study group while taking the upper bound QOL values of the 95% interval for the control group. The upper bound value was calculated vice versa in favor of the study group. With this method, QALY confidence interval lower bound does not provide a positive benefit but rather decreases the patients' utility by 0.0742 QALYs. In contrast, the upper bound provides an increase of 0.1450 QALYs for the patients that take advantage of the stroke-specific coordination service.

After the stroke-specific coordination service's costs and utility were determined, the cost-utility ratio could be established. Based on the costs, which were assessed to be 174.78 € per patient and year¹³, and on the mean gain in QALYs of 0.0975, the stroke-specific coordination service's cost-benefit-ratio is 1792.61 € per QALY. In comparison to other stroke-related interventions the cost-benefit-ratio is very good. For example, stroke units in New Zealand are reported to cost 5100, which is roughly 4000 € at the current exchange rate, per QALY (Te Ao et al., 2012) and stroke units in Germany are reported to cost 3020 € up to 5080 € per QALY depending on the stroke severity (Dodel et al., 2004). Therefore, research hypothesis CBR-2

¹²In Section 6.2 results of the coordination service effectiveness have been presented in more detail.

¹³Refer to Section 6.3.1 for a more detailed description of the stroke manager costs.

Hypotheses	Indicator	Support
CBR-1	Profitable (hospital perspective)	(✓)
CBR-2	Profitable (social perspective)	✓

Table 6.9: Summary of the research hypotheses used to evaluate the coordination service's efficiency (significant support for hypothesis = ✓, borderline support for hypothesis = (✓), and no support for hypothesis = -).

is supported, which states that the stroke manager is profitable from a societal perspective.

The positive values have to be interpreted with caution because of the large confidence interval that ranges from -0.0742 QALYs to 0.1450 QALYs. Nevertheless, the cost-benefit-ratio that is based on mean gain in QALYs is high compared to other interventions. Thus, even though the CBA did not show that the coordination service is completely profitable from the hospital perspective, it is profitable from a societal perspective. Therefore, other healthcare stakeholders should be incorporated. For example, insurance companies, large patient organizations, or outpatient service providers could serve as partner.

6.3.4 Summary

This section evaluated the stroke manager service's efficiency dealing with cost-benefit-ratios from hospital perspective and from societal perspective. Table 6.9 summarizes the research hypotheses that deal with the coordination service's efficiency. For the hospital perspective, the CBA yielded ambiguous results. Costs of the stroke-specific coordination service could be defined precisely because time the stroke manager needs to support an average patient was available. In contrast, monetary value of the benefits could not be determined as easily, because the coordination service provides mostly intangible benefits such as reputation gains. Thus, a range of minimum and maximum monetary benefits was specified with experts from the hospital. These experts determined benefits each supported patient returns minimally or maximally. Since costs for the stroke-specific coordination service were in between the minimal and maximal benefits, research hypothesis CBR-1 was not fully supported nor rejected.

For societal perspective, using the CUA was motivated because it is the state-of-the-art analysis method when inhomogeneous output parameters such as HSQ are compared. Despite the ambiguous results of the CBA from the hospital perspective, the societal perspective yielded a clear benefit for patients that were supported by the stroke manager. Twelve months after stroke incident, at T3, patients from the

study group had a significantly higher HRQOL, which resulted in significant QALY gain if the patients were supported by the stroke manager.

6.4 Coordination Service Acceptance

In this section, results regarding the stroke-specific coordination service acceptance are presented. In contrast to previous analysis – especially compared to the statistical effectiveness evaluation – the provided acceptance results are more of descriptive nature. From patient side, only the population of the study group was considered because the control group did not take advantage of the service. At T2, patients were given a questionnaire about all components of the socio-technical service, i.e. ICT like the stroke health book (SHB), the person stroke manager, and the service concept itself¹⁴. In the following paragraphs, results of each determinant of the developed acceptance model are presented. Major determinants are moderating variables such as gender, age, and prior experience, perceived ease of use, perceived usefulness, and actual use.

There were 17 male and 10 female participants with an average age of 64.67 years¹⁵. Items of the third moderating variable, prior experience with technology, are illustrated in Figure 6.10. Most of the participants clearly stated that they would use an electronic blood pressure device but they were more conservative when it comes to buying or getting information about new products. Yet, they rated themselves as having a positive attitude towards new technology.

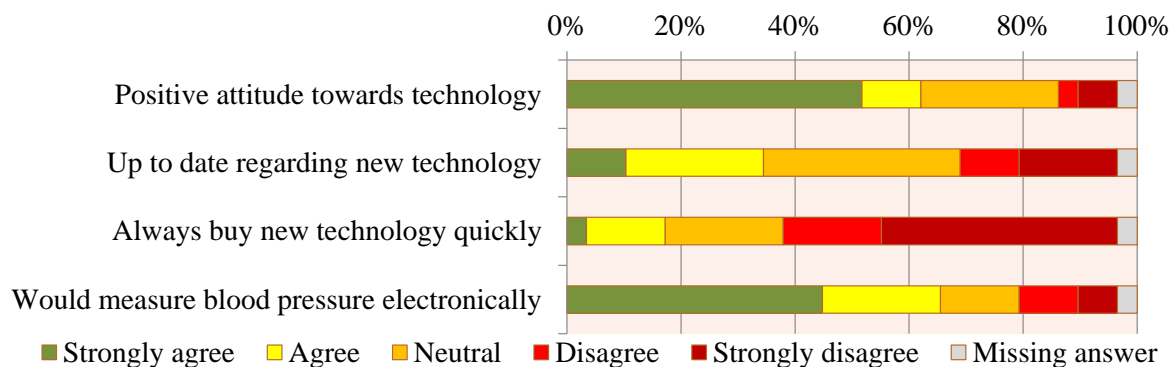


Figure 6.10: Results acceptance evaluation: Prior experience.

Patient answers regarding their opinion about the perceived ease of use are shown in Figure 6.11. The vast majority of the respondents agreed that the person stroke manager was very friendly and was always available when needed. The

¹⁴The complete questionnaire is available in Appendix B.2. Refer to Section 5.2.2 and Section 5.3 for more details about the underlying methodology.

¹⁵Demographics were described in detail in Section 6.1.

same applies to the non-technical aids, particularly the paper-based SHB. They did not rate it as overwhelming as they rated the person stroke manager, yet the majority states that the paper-based SHB was very usable and easy to cope with. In contrast, the responses regarding the ICT components used by patients are mixed. The ease of use of the blood pressure device is mostly positive whereas rating of the electronic SHB ranges from strongly agree to strongly disagree.

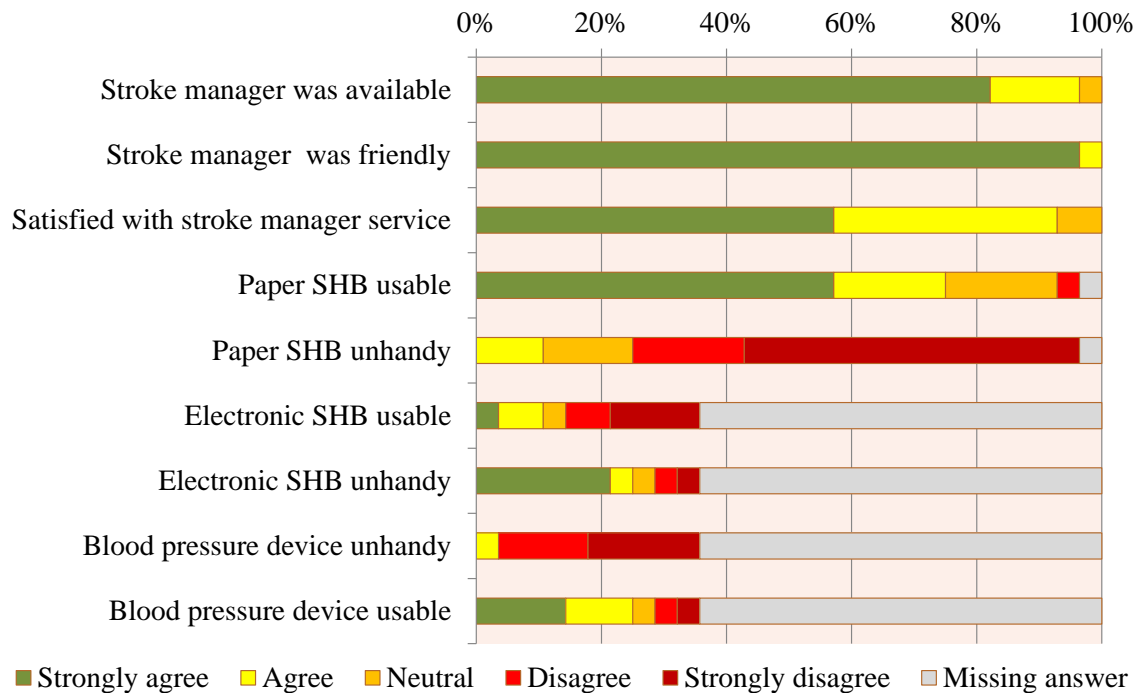


Figure 6.11: Results acceptance evaluation: Perceived ease of use.

The ratings for the perceived usefulness were similar to the perceived ease of use ratings. They are shown in Figure 6.12. Regarding the stroke manager as person, the majority of the respondents agreed that the stroke manager is competent, takes care of their needs, and the service is overall useful. Furthermore, they agreed – even though not as wholeheartedly as for the other usefulness items – that the stroke manager motivates them to live more healthy, that the provided information of the paper-based SHB were useful, and that the calendar in the paper-based SHB was helpful. The respondents disagreed whether more information should have been included or if the comprised calendar was useful. Even though the perceived ease of use of the electronic SHB was rather negative, the perceived usefulness is rated more positively. Especially, the reminders were reported as helpful. However, the patients did not regularly put their medical data in the SHB nor did they take the SHB to the physician.

Apart from the moderating variables and the determinants perceived ease of use and perceived usefulness, the actual use was also inquired from the patients that took advantage of the stroke-specific coordination service. The patient answers

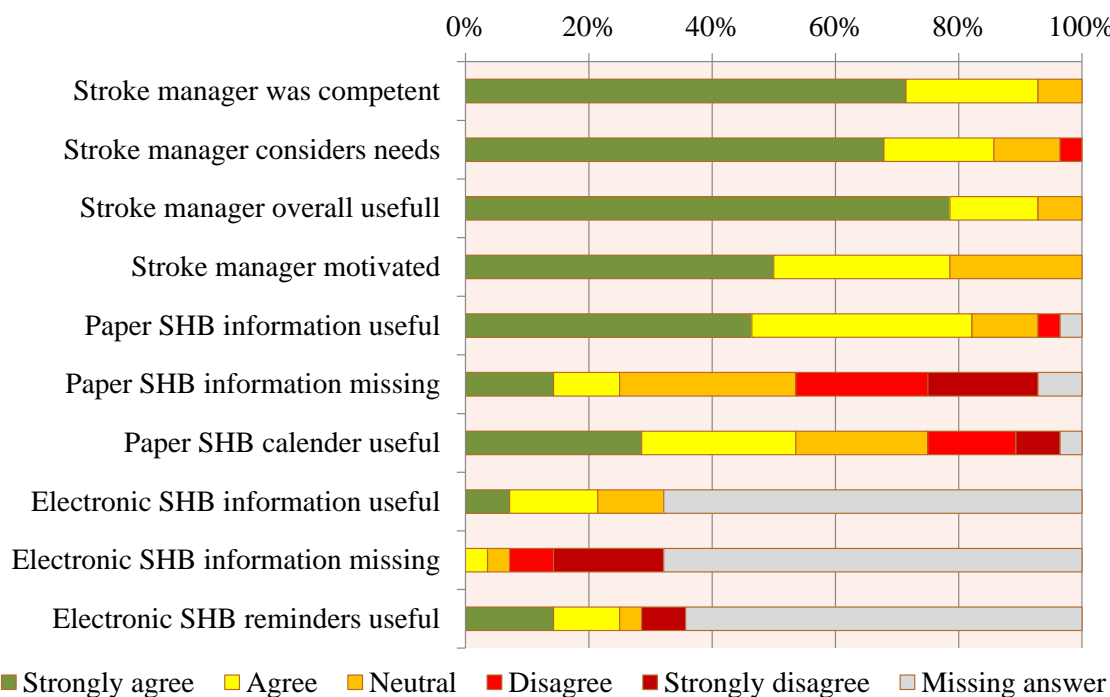


Figure 6.12: Results acceptance evaluation: Perceived usefulness.

are shown in Figure 6.13. More than 90% of the respondents stated that the stroke manager was their first contact if they had stroke-related questions. Almost all of the inquired patients agreed that they would recommend the stroke manager service to others and that they were satisfied with the stroke manager service overall. More than 60% would like to continue to be supported by the stroke manager. Albeit, this number might be biased. Some patients might have hesitated to fully agree because they would not have liked to pay for the service continuation. In fact, most of the patients did not agree that they would pay for such a service. In contrast, about 70% agreed that such a service would be an important factor when choosing their health insurance.

Figure 6.13 also shows that the patients – as much as they actually used the person stroke manager – did not use the provided ICT, i.e. the SHB, or the other supportive components. The additional functions of providing calenders, appointment reminders, or vital charts were neither exploited in the paper-based SHB nor in the electronic SHB. None of the provided SHB were used regularly and taken to the general practitioner as intended during service development. Particularly, the electronic SHB was not used as much as intended because most patients rather wanted to use only the paper-based SHB. Therefore, the ICT components were not used by the patients and they rather used the stroke manager person.

To assess the acceptance of the healthcare service providers, qualitative interviews were administered. Four healthcare service providers, two neurologists and two members of the social service staff were asked in semi-structured interviews

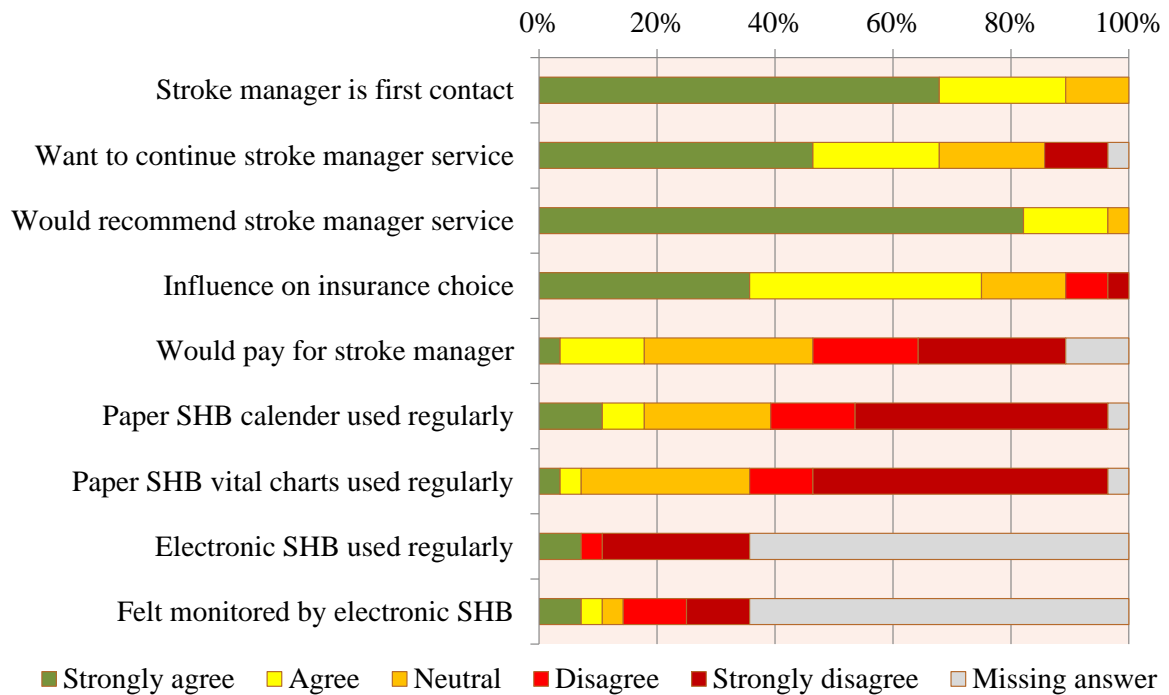


Figure 6.13: Results acceptance evaluation: Actual use.

to rate the stroke manager service similar as the patients had. They also rated the stroke manager as friendly and competent but they did not state that the stroke manager was the first contact with respect to stroke-specific issues. However, since the service providers do not need the support of the stroke manager service as desperately as most of the patients do, the overall rating was not as excellent as the patients'. For the interviewed healthcare providers, the service was rather a "nice to have" support, they happily took advantage off as long as they did not have to put effort in themselves.

In Table 6.10 the results of the acceptance evaluation are summarized. The model that was used in the work at hand to capture patients' attitude towards components of the coordination service provided valuable insights into the patients' acceptance of the coordination service. The stroke manager as a person was rated very well. The patients agreed that the stroke manager was friendly, competent, and their first contact for stroke-related questions. The other components, e.g. the paper-based and the electronic SHB, were rated more controversial. On the one hand, the patients agreed that the provided information were helpful. On the other hand, most patients did not use the calender functions or took the SHB to their general practitioner. In contrast to the SHB, the blood pressure device was rated as usable and the patients did not have any difficulties using it. It is noteworthy that the few patients stated that there were missing information in the electronic SHB than in the paper-based SHB because both included exactly the same information. Perhaps, the information were better accessible on the electronic SHB. Furthermore, the patients

Hypotheses	Indicator	Support
CA-1	Acceptance (Patients)	✓
CA-2	Acceptance (Providers)	✓

Table 6.10: Summary of the research hypotheses used to evaluate the coordination service's efficiency (significant support for hypothesis = ✓, borderline support for hypothesis = (✓), and no support for hypothesis = -).

that did take the SHB to their doctor, rated it overall as more useful. This suggests, that if the SHB is used properly because the patients perceive it as usable, the expected benefit is achieved. Thus, the research hypothesis stating that the patients accept the coordination service is supported. Furthermore, the research hypothesis stating that the service providers accept the coordination service is supported. As long as the service providers do not have to worry too much about the service but rather just take advantage of it, they accept it.

6.5 Conclusion & Discussion

In this chapter, the results of the coordination service's long-term evaluation have been presented. The coordination service has been evaluated in a field study which was set up as medical RCT. There were 105 patients that participated in the RCT, which lasted 18 months. By analyzing the results of the long-term evaluation with respect to effectiveness, efficiency, and acceptance, the three parts of Research Question 3 were studied in detail.

Summary

In Table 6.11 the evaluation results are summarized with respect to the investigated research hypotheses. Most of them were supported. Only the detailed effectiveness evaluation did not yield a clear result. The stroke-specific coordination service significantly improved the patient self-management competences and the intermediate outcome indicators, whereas the neither timely utilization of healthcare services nor the final outcome indicators were significantly improved. Due to the rather short study period, these results were expected for the final outcome indicators. In contrast, it was surprising that the timely utilization of the healthcare services, particularly the social service consultations or the provisioning with additional aids was not increased. However, for all the investigated indicators, even for the final outcome indicators, the patients that were supported by the coordination service had better results than the control group. Furthermore, since the research hypotheses were all investigated with statistical hypotheses postulating no significant difference, the missing significance can also be positively interpreted as study patients

not having worse results than the control group. Thus, the effectiveness evaluation showed that stroke patients that are being supported by stroke-specific coordination service either have better or equal results regarding the indicators for patient-self management competences, timely utilization of healthcare services, final outcome, and intermediate outcome. The efficiency and acceptance analysis showed a positive cost-benefit-ratio and a positive attitude of the involved stakeholders, respectively.

Category	Metric	Support
Effectiveness	Patient self-management competences	✓
	Timely utilization of healthcare services	-
	Final outcome	-
	Intermediate outcome	✓
Efficiency	Cost-benefit-ratio	(✓)
Acceptance	Customer acceptance	✓

Table 6.11: Summary of the coordination service's impact evaluation (significant support for hypothesis = ✓, borderline support for hypothesis = (✓), and no support for hypothesis = -).

Generally, the study data did not provide enough power to significantly support all effectiveness research hypotheses. Even though a power calculation was performed before the study started and the drop-out rate was as expected, the targeted study population was not reached. This had two major reasons. First, many patients did answer the questionnaires but filled them out inconsistently, e.g. forgot to check items. Since many indicators are based on several items on the questionnaire, they were rendered useless despite the patient not being a dropout. Second, due to strict inclusion and exclusion criteria, the recruitment phase lasted longer than expected. Therefore, not all of the initially included patients could be followed up at T3. Even though individual effectiveness research hypotheses may not have been statistically supported, the combined results showed a statistically significant positive effect of the coordination service on the study group compared to the control group.

Regardless of the results' statistical significance, two comparable patient cohorts were recruited. Study group and control group are similar with respect to age, living conditions before the stroke, social environment, stroke severity, and the health state after the acute treatment. Thus, there is no patient sampling bias, which provides validity for the study results.

In detail, the evaluation results show that the study patients have better self-management competences because they know more about the stroke itself, about their situation, and about the available services to support their rehabilitation. Strik-

ing is that even though both patient groups were similar, study group patients stated twice as much that their situation was different after the stroke. This leads to the conclusion that the service has a large impact on patient awareness regarding their situation. In contrast, the study also clearly showed that only awareness and information does not necessarily improve the secondary prevention. The stroke manager did not act as motivating health coach and thus, the secondary prevention was not significantly different between study group and control group. Since the patients from both groups were healthy in comparison to the general stroke population, it was also noticeable that the needed aids, the used outpatient services, the mortality rates, the average level of care, and the re-occurrence rates were rather low. However, the study group's intermediate outcome indicators, particularly HRQOL, were significantly better than the ones from the control group. The latter had a mean score of 0.67 whereas the study group had a mean score of 0.93.

Regarding the efficiency evaluation, the analysis showed that the perspective is important. From a hospital perspective, the stroke-specific coordination service is not profitable under all circumstances. Yet, it has a positive CBR from a societal perspective because it improves the patient's quality of life. Thus, one or more of the HSN stakeholders could cooperate with an insurance to maintain the service profitably while improving patient health.

The acceptance evaluation showed that the coordination service was accepted by all the directly involved stakeholders of the HSN. From the patient side, the personal component of the service was rated positively whereas the ICT components received controversial ratings. Many patients did not use the electronic stroke health book, and those who used it, reported to perceive its usefulness but did not fully agree that it was useful. From the provider perspective, the service was also accepted, albeit not as many providers were involved as originally intended. They rated the service as completely useful as long as they do not have any additional effort.

In addition to the intended evaluation results, the findings of the administered field study have further implications on practical and theoretical level. On the one hand, the gathered data constitutes a unique possibility to improve healthcare services regarding stroke treatment across organizational boundaries. Since the stroke manager had personal contact to the stroke patients in inpatient and outpatient settings, the study provided longitudinal stroke patient data in high detail. This allowed process improvements for the involved organizations. For example, the hospital will monitor the rehabilitation applications of the stroke patients more closely because they were often delayed in between the phases. On the other hand, the study also provides implications for the healthcare service research as well as the information systems community. The evaluated approach to patient-centered coor-

dination in a network of independent stakeholders provides insights into how to incentivized the involved stakeholders by using an independent service.

Implications

As already pointed out in the previous paragraphs, the low power of the study caused by the low quantity of patient data limits the significance of the analysis. Therefore, the data acquired in this study can serve as primer for future studies of ICT-supported, patient-centered coordination. With this study as a basis, it is also safe for future studies to assume that the coordination service has a positive impact. Thus, one-tailed statistical tests are possible which improve the significance with few data. Moreover, the data about the final outcome indicators was insufficient because of the short study time in which the patients were questioned. If followed up for several more years, the data would be more meaningful.

From an engineering point of view, the service engineering cycle has only been completed once because of the long-term evaluation. Only the initial processes and ICT-concepts were adapted. To improve the stroke-specific coordination service's impact, the identified shortcomings regarding the ICT should be addressed. For example, more telemedicine components could be incorporated and new concepts such as mobile apps could be used to integrate patients.

From an organizational point of view, outpatient service providers were not as involved as expected. Since patients in the field study were rather healthy compared to other stroke patients, they did not need as much support and there was not as much contact as expected. In a future setting, either ambulatory service providers should be incorporated more explicitly to provide more benefits for them or patients with worse health states should be included.

Part IV

Finale

Chapter 7

Conclusion & Outlook

This thesis is motivated by the tremendous changes that already are – or in near future will be – caused by the demographic shift and increase in chronic diseases. Due to advancing organizational differentiation and specialization in healthcare, coordination is crucial for efficient – often also for effective – healthcare service provision. While arising economic and technical issues have already been picked up by academia, they are often only investigated from an isolated perspective. Particularly, a patient-centered view along the complete patient care pathway has only been partly addressed by academic literature so far (Kaplan and Porter, 2011). Moreover, apart from several pilot studies, in practice there is no general care coordination concept that provides patient-centered support along the complete care pathway (Bodenheimer, 2008; Cameron et al., 2008). This shortcoming is addressed by the work at hand. It is divided into three self-contained parts with their own contributions. However, since each part is based on the previous ones, the work at hand also provides a holistic view on patient-centered coordination in healthcare service networks. Section 7.1 summarizes the major contributions by revisiting the research questions outlined in Section 1.3. Limitations and future research topics are presented in Section 7.2.

7.1 Contribution & Complementary Research

The main focus is a service-oriented approach to inter-organizational coordination in HSNs that aims at improving the information flow between healthcare stakeholders. In doing so, characteristics of such a coordination service and its long-term effects – particularly with respect to healthcare service quality– are investigated. Hence, this thesis provides insights regarding patient-centered healthcare coordination from a theoretical and from a practical perspective. In detail, three major problems are addressed: 1) even though it is almost "common knowledge" that

inter-organizational coordination in healthcare needs to be improved (see Section 2.2), there are no universal evaluation frameworks; 2) in contrast to the body of literature that recommends a more centralized and patient-centered coordination (see Section 2.3), specific characteristics of such an inter-organizational coordination that does not depend on hierarchical power have not been proposed; and 3) apart from theoretic considerations, there are no long-term evaluations of service-oriented approaches that tackle inter-organizational coordination problems in healthcare. By presenting the development, implementation, and evaluation of a coordination service concept, the work at hand addresses these problems. It thus contributes to current research in service science and information systems by providing a measurement framework for HSQ in HSNs, validated blueprints for an inter-organizational coordination service, and an evaluation of this service in a real-world setting. Particularly in the healthcare domain, such a central, inter-organizational coordination concept that employs a socio-technical system has not been examined neither in theory nor in practice.

As preparation for a theoretically sound service development, this thesis scrutinizes healthcare fundamentals, economic foundations, and state-of-the-art ICT in detail. Drawing from the research fields of service science, organizational theory, and information systems, inter-organizational coordination is investigated in Chapter 2. In this chapter unique characteristics of healthcare services are highlighted and a precise definition of HSQ is given. Existing network concepts are assessed in theory as well as in practice. Furthermore, an HSN is defined as a network of independent healthcare stakeholders along the patient care pathway. Moreover, related work with respect to inter-organizational coordination in healthcare is introduced and discussed, whereas the research gap is pointed out. Thereby, Research Question 1 is addressed.

Research Question 1 <OPERATIONALIZATION OF COORDINATION IN AN HEALTHCARE SERVICE NETWORK >. *How is coordination operationalized in a network of independent healthcare stakeholders in order to assess its quality?*

Section 2.3.3 introduces HSQ in a network context as a means to operationalize coordination. It further relates HSQ's two major parts, healthcare delivery quality and patient health, to the information flow between healthcare stakeholders in an HSN. By decreasing information asymmetries between them, HSQ can be improved. This view extends existing, often insulated perspectives on healthcare coordination that do not live up to real-world scenarios in which an increasing number of patients needs long-term care. Particularly for patients that suffer from chronic conditions, the complete patient care pathway needs to be taken into account when assessing the effects of coordination.

Based on this understanding of inter-organizational coordination, developing and validating a patient-centered coordination service concept is described. The development is performed using a combined software engineering and service engineering approach. The validation is based on a case study approach. Both approaches are presented in Chapter 3. In the development phase, state-of-the-art literature, health-related guidelines, and semi-structured interviews are used to identify service attributes and performance standards. In order to validate these attributes and performance standards, the coordination service is instantiated for a stroke-specific case. Moreover, requirements for a coordination service regarding structures, processes, and legal constraints are derived and validated in a case study (see Section 4.1).

Based on these requirements, a proof-of-concept prototypical service is implemented exploiting ICT for efficient workflows, using telemedicine devices, and providing patient-centered support of the information flow in a regional HSN (see Section 4.2). Since stroke is a disease that has long-term effects on patients and involves many healthcare service providers in inpatient and outpatient settings, it demands high standards of inter-organizational coordination (Barzel et al., 2008; Bodenheimer, 2008). Thus, the developed characteristics can be transferred to other diseases easily (see Research Question 2).

Research Question 2 <CHARACTERISTICS OF THE COORDINATION SERVICE>. *What are the characteristics of an independent service that improves the information flow between the stakeholders of an HSN and, thus, the information management?*

The identified service characteristics contribute a validated coordination concept to IS-related literature in healthcare. Contemporary application-related approaches generally propose a centralized ICT-architecture to improve information management. This does not necessarily comply with the advocated patient-centered approach as pointed out by Porter and Olmstead Teisberg (2006), Winter (2009), and Berwick (2009). Even though all three authors are from different research fields, their argumentation is similar: Such centralized ICT can only be implemented by a large healthcare organization or by the government; and despite numerous promising concepts, such an ICT-architecture is far from being used regularly¹. In order to avoid providing "yet another" coordination concept, its impact evaluation is based on case study. It consisted of evaluating effectiveness, efficiency, and acceptance, addressing Research Question 3.

¹Refer to Section 2.3 in most countries in which contemporary healthcare networks are discussed. This section points out that particularly the large government-driven networks have failed.

Research Question 3 <IMPACT OF THE COORDINATION SERVICE>. *What is the impact of the developed coordination service on the healthcare service quality of a network of independent healthcare stakeholders when it is applied in a real-world scenario?*

The coordination service was evaluated in an 18-months field study² because only during a long-term evaluation the effects of healthcare coordination concepts shown (Ovretveit, 2011). The study results show the service's effectiveness with respect to improving HSQ in an HSN. Particularly, patients' competences and the HRQOL were significantly improved. This is reported in Chapter 6 along with findings regarding the service's efficiency and acceptance. From an IS-perspective, these findings do not dispute the importance of EHRs. Some of the information that was passed on to other stakeholders in the HSN was pulled from EHRs. Nevertheless, the efficiency analysis showed that implementing such a coordination service is far cheaper than implementing an integrated EHR across all the involved stakeholders. In fact, even if interoperable EHRs were introduced, their impact would likely be larger if a patient-centered coordination service supported the various stakeholders in their use.

Further merits of the field study are – apart from the service's impact evaluation – that it provides valuable information for future planning and implementation of socio-technical services in the healthcare domain. It provides success factors such as validated requirements for an inter-organizational coordination service, prerequisites for implementation on-site, e.g. including legal experts early, or a clearer understanding of information patients need and how to provide the information to them. Moreover, a unique pool of process data along the complete patient care pathway is created that can be exploited for further optimization and productivity gains in inpatient and outpatient settings. Findings from the acceptance evaluation can also be transferred to other socio-technical service offerings in healthcare. This thesis provides a contribution for practitioners and researchers alike. Results from all three parts of developing, implementing, and evaluating the stroke-specific coordination service can be exploited by both groups.

For researchers, the achieved results validate the effectiveness of patient-centered care coordination and home telemedicine support, which strengthens prior findings³. Moreover, the results add to the body of knowledge concerning patient-centered and socio-technical aspects of coordination in inter-organizational settings, particularly, when the stakeholders are economically independent. For practitioners, a blueprint of workflows and ICT configuration for a patient-centered coordination service is available that can be implemented easily. Hence, it serves as a valu-

²Refer to Chapter 5 for details on the methodology

³For example, (Berwick, 2009; Abraham and Rosenthal, 2005; Wilson et al., 2012) have proposed similar concepts.

able asset in facing upcoming challenges that are associated with the demographic shift and a growing number of patients suffering from chronic diseases. Since the coordination service does not aim at changing current systems "top-down," it improves information flow between the stakeholders in the contemporary fragmented healthcare systems gradually. As long as it provides the shown benefits (see Section 6.3) for one or more stakeholders of the HSN, there are incentives to supply such a coordination service in a network that supports all HSN participants.

In addition to contributions related to patient-centered coordination, there are also concurrent developments that are not part of this thesis. This complementary research mainly consists of advancing ICT applications and medical practices. Parallel to the research presented in this thesis, the SHB was extended to an independent eHealth app: The Stroke Manager App (SMA). Its basic functions are based on the SHB and adapted to a cross-platform mobile app that runs on most contemporary smart phones and tablets (Görlitz and Hagedorn, 2013). The screenshots in Figure 7.1 show that the SMA provides information, a calendar with reminders, and connections to telemedicine devices that allow measuring blood pressure. Existing functions were extended by games that aim at supporting cognitive and motor skill rehabilitation.



Figure 7.1: Screenshots of the Stroke Manager App on different hardware.

The mobile health app allows usage in every-day scenarios without additional hardware. It provides new possibilities of telemedicine support for patients suffering from chronic diseases. Furthermore, in line with research in the field of health-related quantified self (Gimpel et al., 2013), such an app provides valuable data for all involved stakeholders. Patients benefit from up-to-date information and individual support. For healthcare service providers such an app provides an opportunity to bind patients to their services, i.e. leveraging lock-in effects. Researchers can exploit the provided data to enlarge their knowledge about diseases and their patterns over time.

7.2 Limitations & Future Work

Current developments of ICT-supported, inter-organizational coordination in healthcare have not yet reached a mature stage. In this research area, the work at hand provides a piece of the large puzzle how to improve healthcare coordination. Technical and economical challenges remain to be solved. This section critically discusses the assumptions and constraints that were raised in developing the coordination service. Possible solutions are outlined and future research directions are derived from the suggested solutions.

Advance underlying HSQ model

Since the focus of this thesis is the development and evaluation of a coordination service, the HSQ model that is introduced for operationalizing inter-organizational coordination is only investigated superficially. Nevertheless, it provides a solid basis for further economic analysis because it is based on healthcare-specific literature such as (Donabedian, 1988) and service-oriented literature such as (Engelhardt et al., 1993). For future evaluations explicitly taking a patient-centered perspective, the HSQ model can be utilized. Furthermore, additional model instantiations for other chronic diseases apart from stroke-specific cases would be interesting to compare.

Provide more cases

The underlying case-based approach has several advantages, such as control of confounding variables, an implementation that was close to the service model, and precise feedback of all involved stakeholders because they only referred to one instantiation. Nevertheless, this approach also comes with the disadvantage of having low validity regarding generalization. The large scope of the field study as well as its long-time evaluation do not allow for a multi-center study. Yet, results provided by the analyses suggest that it can be economically worthwhile and – from a patient-centered perspective – sensible to implement the stroke-specific coordination service in several other regions and evaluate its impact. Using the available workflow blueprints and ICT configurations strongly facilitate the implementation.

Furthermore, other implementations could alter the existing blueprints. For example, placing the stroke manager in a rehabilitation facility instead of the acute hospital might yield different results. Another interesting research question concerns scalability of this approach, as several stroke managers may have a large communication overhead between themselves that reduces the positive effects on the information flow.

Transfer to other chronic diseases

Similar to providing more cases with different settings for the stroke-specific coordination service, the general coordination service could be transferred to other chronic diseases. Especially to diseases with patterns that require individual and

long-term support. For example, patients suffering from congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), or an advanced stage of Alzheimer might benefit from an individual, patient-centered support of information flow along their care pathway. In practice, individual information for patients, which were rated as most useful by patients themselves, would have to be adapted to other diseases' circumstances. Here, there are several research questions that are engaging. For example, it is unknown if the effect of the information provision is different when compared across diseases or if there they are more effective when provided using different kind of ICT-support.

Investigate provider cooperation

Based on results of the coordination service's Cost-Benefit-Analysis (CBA) and Cost-Effectiveness-Analysis (CEA), there is large potential for sharing expenditures between the major stakeholder groups in healthcare as they are healthcare service consumers, providers, and payers. From an economic point of view, the possible cooperation of stakeholders and incentives that come along with resource sharing between the involved, independent organizational entities are of interest. For example, questioning the hospital-based perspective of the coordination service is a promising research approach. On the one hand, organizational overhead increases because of additional legal regulations (data security regarding patient data), more external communication with hospital staff, and more complicated interfaces between utilized ICT. On the other hand, such a more general coordination service can support patients from different hospitals or from different stages of the care pathway. This would allow for an extended view of patient selection criteria. In order to evaluate this, additional business cases for large outpatient service providers, insurance companies, or mixed stakeholders should be investigated.

Mobile ICT in patients' homes

Particularly the stroke health book (SHB) provides a fertile field for subsequent research. In the evaluated configuration of the coordination service, the SHB only serves as a tool that allows efficient workflows. As with the CRM tool, which could – at least in theory – be substituted by similar paper work, the SHB could be substituted by more phone calls or even home visits. In addition to simply facilitating existing processes and tasks, the SHB can be expanded. Since it is already adopted and accepted by stroke patients that use it for their regular post-acute treatment, additional functions can be incorporated. For example, further telemedicine devices can be connected that provide medical data not only for patients but also for healthcare service providers, in case they are also connected. Connecting healthcare service providers to a device patients use everyday at home also provides numerous possibilities. Particularly because these patients can not yet take advantage of

digital services because they do not have the necessary access devices. Often they do not even own a computer⁴.

In summary, results presented in this thesis provide valuable insights regarding patient-centered coordination in healthcare service networks. The HSN definition is a novel thought on how to define business networks that needs further theoretical development. From a practical point of view, the developed and evaluated coordination service is a promising approach for ICT-supported case management that improves the healthcare service quality, especially patient health.

⁴Refer to the (N)onliner atlas (Infratest, 2010) for a more detailed description of the target group.

Part V

Appendix

Appendix A

Appendix to Part II

A.1 Interview Guideline - First Set of Interviews

Semi-structured interview guidelines to gain insights into information deficits of stroke patients and how the Internet might serve as a remedy. Listed separately for the different interviewed stakeholders.

Category	Question
General	How long are you in need of care or give care regularly?
	Do you meet other people in need of care or who give care regularly?
	How often do you use the internet and what for majorly?
Available healthcare services	How often do you use the internet to get health information?
	Have you ever visited healthcare portals? If so, which?
	Which criteria are important for online healthcare information?
Requirements for healthcare internet portals	Where should a health portal rather put the emphasis: on information provision, exchange of experiences via online communities or product and service offers?
	Which information would you like to find on a website? information on medical problems, training videos, information about events?
	What kind of services and products would you like to buy online?

Table A.1: Questions for patients and care-giving relatives.

Category	Question
General	How long does your website exist?
	What are the goals of your website?
	Do you want to offer your website in other languages?
	Do you want the website to be frequented by more regional or national/international users?
	Did you create the website yourself or did you have it built?
Available healthcare services	Would you cooperate with other social organizations for website content?
	Have you ever visited healthcare portals? If so, which?
Requirements for healthcare internet portals	Which criteria are important for online healthcare information?
	Where should a health portal rather put the emphasis: on information provision, exchange of experiences via online communities or product and service offers?
	Which information would you put on your website? information on medical problems, training videos, information about events?
	What kind of services and products would you like to put on and sell via your website?

Table A.2: Questions for members of the German stroke foundation.

Category	Question
General	How long are you practicing your job already?
	How often do you meet colleagues and discuss work
	How often do you use the internet and what for majorly?
Available healthcare services	How often do you use the internet to get health information?
	Have you ever visited healthcare portals? If so, which?
	Which criteria are important for online healthcare information?
Requirements for healthcare internet portals	Have you ever offered your services via the internet? If no, would you like to?
	Where should a health portal rather put the emphasis: on information provision, exchange of experiences via online communities or product and service offers?
	Which information would you like to find on a website? information on medical problems, training videos, information about events?
	What kind of services and products would you like to buy online?

Table A.3: Questions for healthcare service providers (home nurses, neurologists etc.).

A.2 Interview Guideline - Second Set of Interviews

Semi-structured interview guidelines to gain insights into current post-acute stroke management. Listed separately for the different interviewed stakeholders.

Category	Question
General	How long has it been since you have had your stroke?
	Which therapists did you go to?
Roles	Were you examined by a general practitioner or a neurologist?
	Are there differences between inpatient and outpatient therapy?
	Were you supported by a social service after leaving inpatient rehabilitation?
	Who was the first contact after leaving inpatient rehabilitation?
	Where you supported by your relatives doing your every day-work?
Interfaces/ resources	Do you meet other patients regularly?
	Were you informed about treatment steps?
	Are there gaps between inpatient and outpatient care? If yes, which?
	Did you get your health record after leaving inpatient treatment?
	Did you get health records during outpatient treatment?
Information exchange	How do you communicate with your family (Email, video telephone, or telephone)?
	How do you communicate with your doctor (Email, video telephone, or telephone)?
	Did you have all necessary information after leaving inpatient treatment?
	Which types of exercises are you doing at home?
	Did you have a follow-up?
	When were you informed about the next steps of your ongoing therapy?

Table A.4: Questions for patients and care-giving relatives.

Category	Question
General	How many stroke patients do you regularly take care of?
	How long is such a therapy regularly?
	How many times do you treat one stroke patient?
	Who determines the stroke patient's therapy plan?
Roles	Are there conflicting interests between therapist and patient?
	What discussions take place between general practitioner and neurologists?
	How often do you call the general practitioner?
	Who do you keep regular contact with (e.g. care-givers, other therapists etc.)?
Interfaces/ resources	Are your services chosen freely by patients or are they rather recommended?
	Are there gaps between inpatient and outpatient care? If yes, which?
	Which type of data do you need for your work?
	Who needs to provide this data?
Information exchange	How do you exchange information/ data with other healthcare providers?
	Do stroke patients know about necessary aids and adjustments at home?
	When were you informed about the next steps of your ongoing therapy?
	Do you think more information exchange between healthcare providers is beneficial?

Table A.5: Questions for healthcare service providers (ambulatory care and therapists).

Category	Question
General	How many stroke patients do you regularly take care of?
	How long is such a therapy regularly?
	How many times do you treat one stroke patient?
	Who determines the stroke patient's therapy plan?
Roles	Are there conflicting interests between doctor and patient?
	Who do you keep regular contact with (e.g. care-givers, therapists etc.)?
	Are there gaps between inpatient and outpatient care? If yes, which?
	Are your services chosen freely by patients or are they rather recommended?
Interfaces/ resources	What are the deficits in the transition phase between inpatient and outpatient treatment?
	Which type of data do you need for your work?
	Who needs to provide this data?
	How do you exchange information/ data with other healthcare providers?
Information exchange	When do you inform patients and other providers about next steps of the therapy?
	Do you think more information exchange between GP and therapists is needed?

Table A.6: Questions for healthcare service providers (general practitioner and neurologist).

Appendix B

Appendix to Part III

B.1 Timeline of Development and Evaluation

Table B.1 shows major events during development and evaluation of the stroke-specific coordination service. Particularly, major events when preparing and conducting the stroke manager field study are described. It lists date and description of major events influencing the study process.

2010-10-01	Constitution of the working group responsible for the field study.
2010-11-12	First set of interviews with various healthcare service providers and patients to assess the benefit of the Internet in providing individual information.
2011-05-15	Second set of interviews with various healthcare service providers and patients to identify requirements and key functions of the coordination service.
2011-06-22	Workshop with various healthcare service providers: Assessment of the interview results and requirement analysis of the coordination service.
2011-07-12	Workshop with hospital staff and patients: Development and preparation of individual stroke information and requirement analysis of the SHB.
2011-09-15	Workshop with hospital staff: Final evaluation of the CRM-tool.
2012-01-01	Pretest of the CRM-tool and questionnaires for two months at the hospital in a real-life environment: Preparation of checklists and instruction manuals for use in practice.
2012-02-01	One month pilot phase with typical stroke patient and care-giving relative to evaluate the individual information material in practice.
2012-03-05	Workshop with patients: Evaluation of the SHB in practice.
2012-04-01	Start of the stroke manager study – pretest for two months.
2012-06-12	Adaptation of the exclusion criteria: Patients do not necessarily have to be brought to the hospital using the emergency service and live in close vicinity.
2012-06-18	Adaptation of the inclusion criteria: Only head physicians working at the stroke unit when stroke patients are admitted to the hospital asks them to participate in the field study.
2012-09-01	Stroke Health Books (SHBs) have been distributed to the hospital staff for on-site testing.
2012-11-28	Type of blood pressure devices connected to the SHBs have been changed and all sets.
2013-03-05	Addition to stroke patient follow-up questionnaires at T1 and T3: Patients are asked to report their medication.
2013-04-01	Stroke Manager computer gets dedicated internet connection.
2013-06-30	CRM-tool update: Better Outlook integration regarding appointments and tasks.

Table B.1: Timeline of major events when developing the stroke-specific coordination service and conducting the stroke manager field study.

B.2 Questionnaires at T1 and T3

During the field study, data was acquired from patients of study group and control group at T1 and T3. In order to assess the coordination service's effectiveness, data about healthcare delivery quality and patient health was – among other sources – acquired from patients in follow-up telephone interviews and surveys. The data acquisition was administered in two stages to minimize the drop-out rate of patients. In the following two sections, the telephone questionnaire and the postal questionnaire that was sent out to the patients at T1 are shown.

At T3, the same questionnaires were used except for several questions that are only relevant after discharge. For telephone questionnaire at T3, items three and four were excluded. For the postal questionnaire at T3, item six was adapted to the appropriate time frame.

B.2.1 Telephone Questionnaire at T1 and T3

1. Do I speak with <name>?
 - Yes
 - No (If possible, get patient on the phone. If not possible, ask why.)
 - Deceased (If possible, ask when <name> died)
 - Moved
 - Lives in a nursery home
 - Patient is not capable of talking on the phone
 - Not available

2. You were from <date> to <date> at the NKG because of a stroke. I would like to talk about your current health state and the stroke's repercussions. I would like to ask several questions via phone and send out a survey to your home address afterwards. The phone part will take about 10 minutes. Data will be recorded anonymously and we treat your provided answers with confidentiality. Furthermore, recorded data will only be evaluated regarding the stroke manager study and will not have any influence on your current or future treatment at NKG or other providers. Do you provide your consent to give us anonymous information about your health state?
 - Yes
 - No -> Good bye

3. Has your situation changed drastically after the stroke?
 - Still in inpatient treatment

- No
- Yes -> ask the following questions
 - (a) Was everything well prepared for when returned home?
 - Yes
 - No -> What was missing?
 - Not necessary
 - (b) Where you given enough information about possible financial support during discharge?
 - Yes
 - No -> What was missing?
 - Not necessary
 - (c) Where you given enough information about possible outpatient health-care services during discharge?
 - Yes
 - No -> What was missing?
 - Not necessary
 - (d) Where you given enough information about miscellaneous services during discharge?
 - Yes
 - No -> What was missing?
 - Not necessary
 - (e) Do you receive all necessary support at the moment?
 - Yes
 - No -> What was missing?
 - Not necessary
- 4. Did you visit the social service?
 - No
 - Yes
- 5. Have you had to visit the hospital again after your stroke at <date>?
 - No (If possible, ask when)
 - Yes - because of a stroke
 - Yes - because of a heart attack
 - Yes - because of something else
- 6. What is your current living condition?
 - Alone
 - With your partner
 - With family or relatives

- Nursery home or institution
- Miscellaneous

7. Where your living conditions the same before the stroke? (Check current address, maybe changes are already visible.)

- Yes
- No -> ask the following question

(a) How was it before?

- Alone
- With your partner
- With family or relatives
- Nursery home or institution
- Miscellaneous

8. Have you worked regularly before the stroke incident?

- No
- Yes -> ask the following question

(a) How is your current occupational situation? Fully employed

- Part-time
- Unemployed
- Premature retirement
- Retirement
- Sick
- Miscellaneous

9. Have you made any changes to your house in the last weeks or months?

- No
- Yes -> ask the following question

(a) What have you changed?

- Handrail
- Low reading armchair
- Suitable bed
- Changes to bath room or toilet
- Bath lift
- Better lighting in any room
- SOS phone
- Miscellaneous

10. Do you need additional aids?

- No

- Yes - Which?
 - Wheelchair
 - Surgical stockings
 - Orthopedic shoes
 - Miscellaneous
11. Have you been introduced in using the additional aids?
- Not necessary
 - No - Which?
 - Yes - When?
12. Do have somebody that takes care of you?
- No
 - Yes - care-giving relative
 - Yes - regular care of nursing service
 - Yes - nursery home Pflegeheim/ Institution
 - misc:
13. What is your official level of care?
- None
 - Level of care 0
 - Level of care I
 - Level of care II
 - Level of care III
 - Level of care requested
 - I don't know

B.2.2 Postal Questionnaire at T1 and T3

Dear patient, please fill out the questionnaire and send it back to NKG until <date>. Your answer are recorded anonymously and are treated strictly confidential. If you need help, please ask friends or relatives for support. Please check the right answer for each question.

A) Mobility

- I have no problems in walking about
- I have some problems in walking about
- I am confined to bed

B) Self-Care

- I have no problems with self-care
- I have some problems washing or dressing myself

I am unable to wash or dress myself

C) Usual Activities (e.g. work, study, housework, family or leisure activities)

I have no problems with performing my usual activities

I have some problems with performing my usual activities

I am unable to perform my usual activities

D) Pain/Discomfort

I have no pain or discomfort

I have moderate pain or discomfort

I have extreme pain or discomfort

E) Anxiety/Depression

I am not anxious or depressed

I am moderately anxious or depressed

I am extremely anxious or depressed

F) My current health state compared to three months ago is

Better

Similar

Worse

To help people say how good or bad a health state is, we have drawn a scale (rather like a thermometer) on which the best state you can imagine is marked 100 and the worst state you can imagine is marked 0.

We would like you to indicate on this scale how good or bad your own health is today, in your opinion. Please do this by drawing a line from the box below to whichever point on the scale indicates how good or bad your health state is today.

**Your own
health state
today**

Best
imaginable
health state

100

90

80

70

60

50

40

30

20

10

0

Worst
imaginable
health state

Figure B.1: Graphic used to retrieve stroke patients' VAS health state as provided by the EuroQol Group (1990).

1. Do you need someone that supports you during your housework (like choosing your clothes, taking away your clothes, doing the dishes)?
 No
 Yes

2. Do you need someone that supports you regarding financial issues?
 No
 Yes

3. Do you need someone that helps you using public transport, driving a car, etc.?
 No
 Yes

4. Do you need someone that supports you do your errands?
 No
 Yes

5. Did your ability to work change since you have had the stroke?
 No
 Yes

6. Did your capability to care for your family change since you have had the stroke?
 No
 Yes

7. Did your hobbies change or do you have difficulties conducting them as usual?
 No
 Yes

8. Do you have difficulties reading, writing, or finding the right words when talking?
 No
 Yes

9. Do you have coordination or balancing problems?
 No
 Yes
10. Do you have numb body parts or lost movement abilities (face, arms, legs or hands)?
 No
 Yes
11. Do you have swallowing difficulties?
 No
 Yes
12. How do you move around your house or apartment?
 I am able to move by myself (maybe by using a walking stick)
 I am only able to move when someone helps me
 I am only able to move by using a wheelchair
 I cannot move at all
13. How much support do you need?
 I need no help when getting up or sitting down in a chair.
 I am able to change positions from bed to chair with a little support.
 I need someone to help me move from bed to chair. I am able to sit on my own.
 I am not able to sit in a chair or have to stay in bed all the time.
14. Do you need help when walking up stairs?
 I do not need help walking up stairs.
 I need help walking up stairs.
 I am not able to walk up stairs.
15. Do you need help when eating?
 I do not need help during meals (meal can be cooked or prepared by one another person).
 I need help when eating (e.g. cutting pieces).
 I am not able to eat a normal meal and have to eat specially prepared food

(mashed meals or PEG tubes).

16. Do you need help when dressing or undressing (including buttons and closing the zipper)?
- I do not need help for dressing or undressing.
 - I need some help when dressing or undressing. I am able to put on or take off some of my clothes on my own.
 - I am not able dress or undress by myself.
17. Do you need help when taking a bath or a shower?
- I do not need help when taking a bath or a shower. I get in and out of the bathtub by myself and I am able to clean myself.
 - I need help when taking a bath or a shower.
18. Do you need any help for personal hygiene (brushing your teeth, putting in your teeth, combing your hair, shaving and cleaning your face)?
- I do not need help for personal hygiene.
 - I need help for personal hygiene.
19. Do you need help when using the toilet, sit-down and get up, taking on or off the clothes or cleaning your back?
- I do not need when using the toilet.
 - I need help some help when using the toilet. I am able sit down, get up, or take off clothes on my own.
 - I need help when using the toilet.
20. Did you have any problems when using the toilet last week?
- I did not have any problems when using the toilet (or I can use the catheter on my own).
 - I sometimes loose control of my bladder, but only once a day.
 - I loose control of my bladder more than once a day (or I can't use the catheter on my own).
21. Did you have any problems with bowel movement last week?
- I did not have any problems.
 - I sometimes loose control of my bowel movement, but not more than once a week.

- I loose control of my bowel movement more than once a week.
22. Do you or did you ever smoke?
- Yes, I smoke cigarettes, cigars, or a pipe.
 - Yes, I have smoked cigarettes, cigars, or a pipe
 - No, I have never smoked.
23. How often do you drink alcoholic drinks (beer, wine, or spirits)?
- Almost every day.
 - Several times a week.
 - Once a week or less.
 - I drink no alcoholic drinks.
24. How often do you do physical activities (e.g. doing sports, garden activites, or going for a walk)?
- Almost every day.
 - Several times a week.
 - Once a week or less.
 - I do not perform any physical activities anymore.
25. How often do you measure your blood pressure?
- Almost every day.
 - Several times a week.
 - Once a week or less.
 - I do not measure my blood pressure.
26. Please note your weight and your height here:
27. I know my personal risk to get a stroke and know how to reduce it.
- Yes
 - Almost yes
 - Almost no
 - No
28. What kind of supporting services do you know? (You can check more than one answer)

- Common service station
- Stiftung Deutsche Schlaganfall-Hilfe
- Ambulatory healthcare services
- Mobile social services
- Mobile driving services
- Mobile washing services
- SOS call service
- Meal on wheels
- Visitation programs
- Organized neighborhood support
- Self support groups
- Crisis consultation
- Psychological consultation
- Ambulatory occupational therapy
- Ambulatory speech therapy
- Ambulatory physical therapy

29. What kind of supporting services do you know? (You can check more than one answer)

- Common service station
- Stiftung Deutsche Schlaganfall-Hilfe
- Ambulatory healthcare services
- Mobile social services
- Mobile driving services
- Mobile washing services
- SOS call service
- Meal on wheels
- Visitation programs
- Organized neighborhood support
- Self support groups
- Crisis consultation
- Psychological consultation
- Ambulatory occupational therapy
- Ambulatory speech therapy
- Ambulatory physical therapy

30. Please provide additional comments here:

B.3 Questionnaire at T2

At T2, only the study group patients were provided with a postal questionnaire to evaluate the coordination service's acceptance. It comprised the following introductory paragraph and questions provided in the following four tables. Only patients that used an electronic SHB were asked to answer the questions provided in the fourth table. Due to readability reasons, the likert scale items that were originally spelled out fully in the administered questionnaires are shortened. Strongly agree, agree, neutral, disagree, and strongly disagree are signified by 1 through 5 in the following tables.

B.3.1 Postal Questionnaire at T2

Dear patient, thank you very much for taking part in the stroke manager study. You are one of the first participants and provide very valuable data for improving stroke patients' support. Based on this questionnaire we want to assess the stroke manager concept and improve our services. Please check only one box in each line – each statement. The more you check on the left side, the more you approve to the statement.

	1	2	3	4	5	6
The stroke manager is my first contact when having questions related to stroke.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The stroke manager was always available.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The stroke manager was always friendly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The stroke manager was competent.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The stroke manager considers my needs.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am satisfied with the stroke manager service.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The stroke manager motivates me to live more healthy.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would recommend the stroke manager service to others.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am completely satisfied with the stroke manager.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Programs like the stroke manager influence my choice of insurance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would be willing to pay for a service like the stroke manager.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Table B.2: Questions regarding the stroke manager service (1: Strongly agree, 2: Agree, 3: Neutral, 4: Disagree, 5: Strongly disagree, 6: No answer).

The paper SHB was usable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The paper SHB was unhandy.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The information in the paper SHB was useful.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There were information missing in the paper SHB.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The calender in the paper SHB was useful.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I used the calender in the paper SHB regularly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The vital charts in the paper SHB was useful.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I used the vital charts in the paper SHB regularly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My doctor knew more about my health state because of the paper SHB.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Table B.3: Questions regarding the additional components (1: Strongly agree, 2: Agree, 3: Neutral, 4: Disagree, 5: Strongly disagree, 6: No answer).

I have a positive attitude towards technology.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am always up to date regarding new technology.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I always buy new technology quickly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would use an electronic blood pressure device.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Table B.4: Questions regarding your attitude towards new technologies (1: Strongly agree, 2: Agree, 3: Neutral, 4: Disagree, 5: Strongly disagree, 6: No answer).

The electronic SHB was usable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The electronic SHB was unhandy.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The information in the electronic SHB was useful.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There were information missing in the electronic SHB.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The blood pressure device was usable.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The blood pressure device was unhandy.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The reminders in the electronic SHB were useful.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I used the reminders in the electronic SHB regularly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The vital charts in the electronic SHB were useful.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I used the vital charts in the electronic SHB regularly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
My doctor knew more about my health state because of the electronic SHB.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I felt monitored by the electronic SHB.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Table B.5: Questions regarding the electronic components (1: Strongly agree, 2: Agree, 3: Neutral, 4: Disagree, 5: Strongly disagree, 6: No answer).

B.4 TTO Calculation using EQ-5D

The answers in the postal questionnaires from T1 and T3 provide EQ-5D values in the first five questions: A) Mobility, B) Self-Care, C) Usual activities, D) Pain/discomfort, and E) Anxiety/depression. From these EQ-5D values, QOL value can be calculated using the following formula: $QOL_{TTO} = \alpha + \beta_1MO + \beta_2SC + \beta_3UA + \beta_4PD + \beta_5AD + \beta_6M_2 + \beta_7S_2 + \beta_8U_2 + \beta_9P_2 + \beta_{10}A_2 + \beta_{11}N_3$

This formula was proposed by Greiner et al. (2005) and is based on the time trade off (TTO) calculation. It has been verified for the German population. Coefficients α and β_i signify population-based preference values. The former signifies the initial state of full health, which is 0.999 for the German population according to the TTO regression analysis (Greiner et al., 2005). The latter coefficients β_1 to β_{11} signify the German preference values. The QOL_{TTO} value ranges from -0.59 to 1. The value '1' (EQ-5D: 11111) represents absolute health whereas '0' expresses a QOL comparable with death. This formula allows QOL values lower than 0 because the TTO is calculated by deducting from the original health state of '1' – for the German population 0.999. For the regression model to fit for QOL between 0 and 1, this allows negative QOL values in extreme cases, which can only be interpreted as rather being dead than live in the current health state. Table B.6 shows variables and coefficients for the QOL calculation. Variables MO through N3 depend on the EQ-5D values and coefficients β_i are based on the TTO calculation.

Var	Value	Coef	Value
MO	If Mobility has been marked as moderate 1	β_1	-0.100
	If Mobility has been marked as extreme 2	β_1	-0.100
	Else 0	β_1	-0.100
SC	If Self-care has been marked as moderate 1	β_2	-0.067
	If Self-care has been marked as extreme 2	β_2	-0.067
	Else 0	β_2	-0.067
UA	If Usual Activities has been marked as moderate 1	β_3	-0.014
	If Usual Activities has been marked as extreme 2	β_3	-0.014
	Else 0	β_3	-0.014
PD	If Pain/Discomfort has been marked as moderate 1	β_4	-0.114
	If Pain/Discomfort has been marked as extreme 2	β_4	-0.114
	Else 0	β_4	-0.114
AD	If Anxiety/Depression has been marked as moderate 1	β_5	-0.006
	If Anxiety/Depression has been marked as extreme 2	β_5	-0.006
	Else 0	β_5	-0.006
M2	If Mobility has been marked as extreme 1	β_6	-0.130
	Else 0	β_6	-0.130
S2	If Self-care has been marked as extreme 1	β_7	-0.040
	Else 0	β_7	-0.040
U2	If Usual Activities has been marked as extreme 1	β_8	0.038
	Else 0	β_8	0.038
P2	If Pain/Discomfort has been marked as extreme 1	β_9	-0.084
	Else 0	β_9	-0.084
A2	If Anxiety/Depression has been marked as extreme 1	β_{10}	-0.060
	Else 0	β_{10}	-0.060
N3	If any EQ-5D value has been marked as extreme 1	β_{11}	-0.318
	Else 0	β_{11}	-0.318

Table B.6: TTO calculation and German preference valuation based on Greiner et al. (2005).

B.5 Bootstrapping Results

		Mean \pm SD (study data)		Mean \pm SD (bootstrap)	
		Control group	Study group	Control group	Study group
BI	T0	93.87 \pm 8.03	92.06 \pm 13.76	93.77 \pm 4.17	91.51 \pm 13.40
	T1	95.32 \pm 11.02	95.61 \pm 12.48	94.65 \pm 13.31	95.18 \pm 15.61
	T3	89.17 \pm 16.62	98.57 \pm 3.78	88.38 \pm 14.97	97.50 \pm 5.48
mRS	T0	1.19 \pm 1.07	1.32 \pm 1.05	1.22 \pm 0.51	1.32 \pm 0.50
	T1	1.19 \pm 1.25	1.42 \pm 1.27	1.21 \pm 0.36	1.42 \pm 0.38
	T3	1.50 \pm 1.31	0.57 \pm 1.13	1.49 \pm 0.55	0.75 ^a \pm 1.64 ^a
TTO	T0	0.83 \pm 0.08	0.82 \pm 0.13	0.84 \pm 0.04	0.81 \pm 0.14
	T1	0.86 \pm 0.20	0.86 \pm 0.18	0.86 \pm 0.21	0.86 \pm 0.18
	T3	0.67 \pm 0.35	0.93 \pm 0.08	0.68 \pm 0.30	0.94 ^b \pm 0.12 ^b

Table B.7: Bootstrap results for Barthel-Index (BI), modified Rankin Scale (mRS), and time trade off (TTO) based on 1000 bootstrap samples, unless otherwise noted (^a: 997 samples and ^b: 998 samples).

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