Productivity of Telemedical Services: A State of the Art Analysis of Input and Output Factors

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We present a state of the art analysis on input and output factors for services in the field of telemedicine by applying a systematic literature review. Our results show that no attempts for the systematic identification of a set of input and output factors have been conducted so far, and the systematic consideration of all stakeholders is not adequately addressed in literature. We further identified and present input and output factors that we assigned to 16 categories and assessed their relevance for the stakeholders of the telemedicine sector. Our study hence contributes to research activities within service productivity and can serve as a starting point to develop comprehensive productivity models for telemedical services (TMS).

1. Introduction

Telemedicine is the provision of medical services over geographic distances through the use of information and communication technology (DGTelemed, 2011). The global telemedicine market is expected to grow from $9.8 billion in 2010 to $23 billion in 2015 (BCC Research, 2011). The telemedicine sector is characterized by its heterogeneous stakeholders such as patients and their relatives, physicians and clinical personnel, IT service providers and professionals and hospitals as well as health insurance companies.

Despite the technical development of recent years and the advances in research on telemedical services (TMS) today, most developed services are hardly used in daily routines (E-Health-Server, 2011). In the German healthcare system, this is mainly due to the lack of support and financial funding through the statutory health insurance companies which serve almost 90% of the German population (Bundesärztekammer, 2011). This issue is predominantly caused by a lack of proven cost-effectiveness studies on TMS. In order to benefit from possible cost-savings and potential improvements in the quality of medical services (Inglis, 2010), statutory health insurances as well as other potential financers need to be convinced of the cost-effectiveness of TMS. Well-established means for this are studies following the standards and routines of clinical trials for medical treatment studies. Furthermore, all other stakeholders involved in TMS need to accept and support the usage of telemedicine as only seamless end-to-end solutions deliver the value proposition of TMS (Schweiger et al., 2007). Hence, productivity of these services and the according empirical evidence is a key requirement for the diffusion of TMS in the healthcare system. This requires productivity measurement methods based on the identification of relevant input and output factors of TMS. Additionally, these factors also need to be assessed on their relevance to the respective stakeholders. Hence, our paper addresses the following research questions (RQ):

RQ1: Which input and output factors for productivity analysis of TMS can be found in the existing body of literature? (section 4)

RQ2: For which stakeholders are the identified factors of relevance? (section 5)

We answer these research questions by conducting a systematic literature review.

When analyzing TMS and their productivity, it is of utmost importance to benchmark. For TMS, the corresponding benchmark is traditional, people-bound service provisioning without the use of IT or telemedicine (Menschner, Peters, Leimeister, 2011). Additionally, TMS enables completely novel and unknown services which are not comparable to traditional service provision (Menschner et al., 2011). To exemplify this, a telemedical defibrillator which manages to send data in continuous time intervals can be considered. In a traditional, people-bound setting, this would represent a treatment requiring a 24/7 patient care, which is not possible or affordable in reality.

The remainder of the paper is structured as follows: In section 2, the used terminology is presented and clarified. Section 3 outlines the approach and methodology we used for the literature review. Then, the main results of this paper, namely the identified input and output factors, are presented and discussed in section 4, followed by an assessment of their relevance for the stakeholders of the telemedicine sector in section 5. We close with limitations and future research in section 6 and draw a conclusion which articulates the contribution of our paper.

2. Terminology

Productivity is a term that is widely used, but defined context-dependent in various ways. That’s why we would like to present the terminology underlying our research and the presented literature review. Our understanding of productivity is based on the definitions of (Slack, Chambers, Johnston, 2004). According to these authors, productivity is calculated as the ratio of output and input resources, whereby inputs and outputs are defined as follows:

Input resources are the transforming and transformed resources that form the input to operations. Inputs contain materials and information (transformed resources) as well as facilities and staff (transforming resources). Outputs are the products and services, which result from the transformation process of the defined inputs.

(Slack, Chambers, Johnston, 2004) refer to operations management in general and not specifically to service operations and set the focus on the transformation process. For service operations, the customer plays a special role; they represent transformed resources as being the treatment object on the one hand and are transforming resources in the role of a co-creator of the service on the other hand. In their contribution to service operations management, (Johnston, Clark, 2001) consider the customer as explicit input factor in the service-related productivity model and also account for the long term effects of the service delivery on the customer. (Johnston, Clark, 2001) denote these effects as the outcome of a service. In the context of health-related services, the role of the patient as active participant of the service delivery process is considered widely. Our results in section 4 underpin this clearly. In addition to this, outcomes are regularly the focus of an evaluation, as especially the long-term-effects on the patient, e.g. improvement of health status, are a primary aim of service delivery (although the aim of the intervention can be different and depends on the stakeholder perspective). Considering the great importance of input by the patient as well as outcome measurement in health services evaluation, affirmed by our literature review, we extend our understanding of productivity taking these points as integral part of productivity into account.

Apart from the definition and measurement of the outcomes of TMS, respective evaluations usually consider the effects of telemedicine in comparison to alternative treatments, e.g. the change in direct costs of an intervention or reduction of process time, and present these results as an outcome of the service delivery. It might be arguable to capture these issues as a reduction of input factors according to the definition given above. In our literature review, we capture the current state of the art of productivity analysis of TMS. Thus, we included items which are based on comparisons to alternative treatments on the output / outcome side. This representation follows the structure of the reviewed studies.

3. Methodology

We were mainly interested in identifying articles that contribute to the body of knowledge of service productivity within telemedicine, i.e. articles providing studies that provide insights on service productivity and input / output analysis of services in the particular field of TMS. We started with a systematic literature review which was performed on the online databases IEEE, ACM and Science Direct. Thus, we cover a broad range of peer-reviewed publications. To consider the very specific type and environment of TMS, the search has been extended to the database PubMed with focus on key words relating to health economic evaluation in the context of telemedicine. The search comprised the key words “service productivity” and “telemedicine” / “ehealth”, “health economic evaluation” and “telemedicine” / “telemonitoring” as well as “input / output factors” / “costs” / “productivity” / “effectiveness” / “efficiency” and “telemedicine” / “telemonitoring” and their corresponding abbreviations. The search has been limited to the fields “title”, “keywords” and “abstract”. The review time period was from 2000 to 2011.

The initial search returned almost 3000 articles. Accounting for duplicate results and after a preliminary scan of the article abstracts, the number of articles to be included was substantially reduced. Reasons for excluding articles were, among others, non TMS relevant articles and articles dealing only with technical feasibility or medical effectiveness. Finally, 161 relevant journal and conference articles, as well as books and book chapters, were included in the review. The overall process of our review is displayed in Figure 1 below.

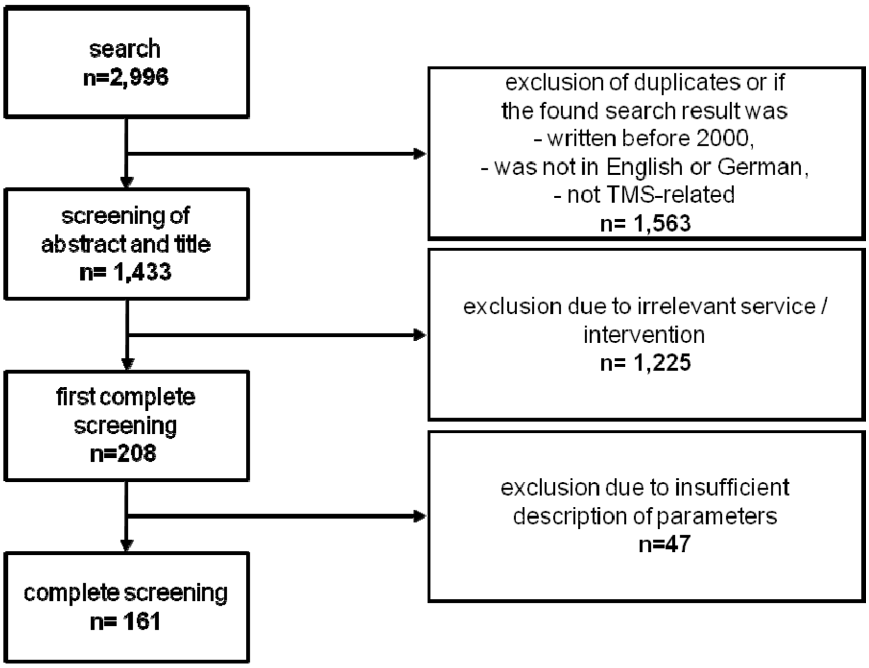

Fig. 1: Overview of the systematic review process

4. Results

Through the thorough literature review more than 160 articles could be identified and their analysis leads to the following results and reveals clear research gaps (RG). Input factors such as direct costs or process time and outcome factors such as health-related quality of life could be identified. Also, the existing body of literature presents several TMS for which effectiveness studies are presented.

RG1: Until now, no attempts for the identification of a comprehensive set of input and output factors for TMS have been conducted in the analyzed literature.

RG2: The systematic consideration of all stakeholders in the telemedical context does not seem to be adequately addressed in existing literature.

Due to the many productivity-related factors, we created an overview figure for clarity and manageability reasons. The derived categories are the result of interdisciplinary discussion sessions. The presented overview contains nine input and seven output/outcome categories and is displayed in Figure 2 below. Each item is dedicated to one category. Still, categories named identically do not comprise the same items, e.g. costs are considered as financial-related input and reimbursements/revenues as financial-related output. The allocation of the items to the categories depends on the type of the TMS and may not be valid for every TMS.

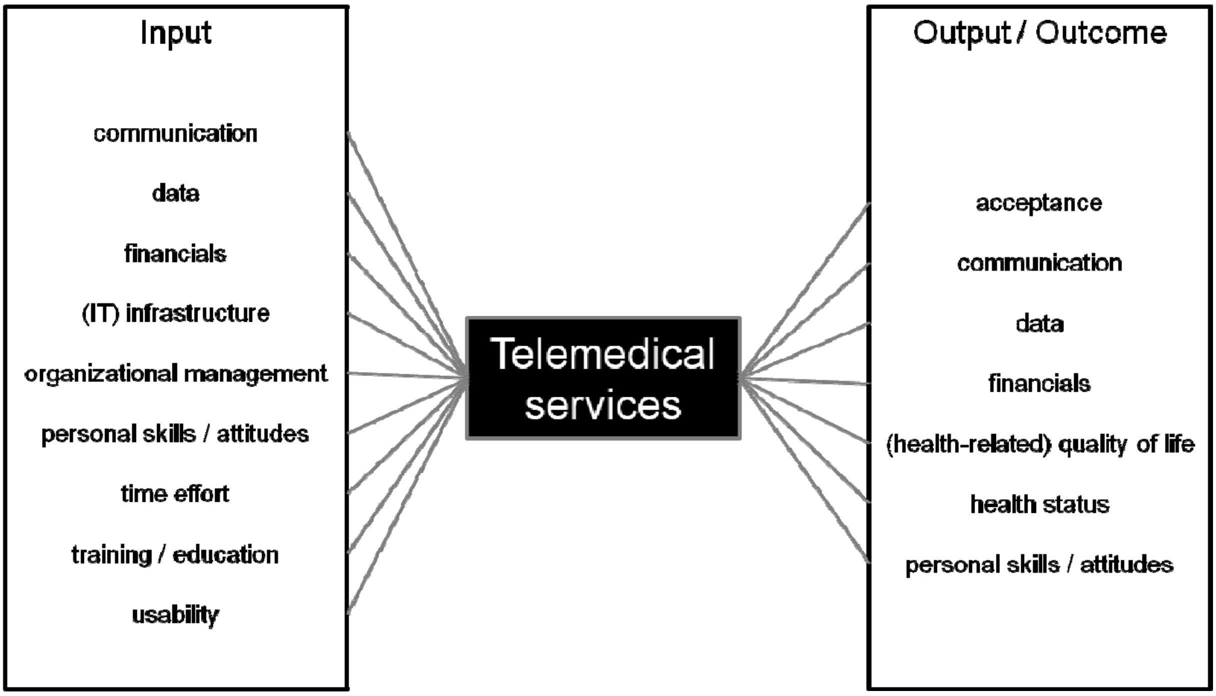

Fig. 2: Categories of Input and Output / Outcome Factors

There is one dedicated subsection for each input factor (see section 4.1) and each output / outcome factor (see section 4.2). The subsections are presented in alphabetical order and are structured the same way: First, the category is briefly described. Second, examples for factors from the studied body of literature are outlined.

4.1. Input Factors

We clustered over 50 different input items to the nine categories. Each item refers to only one category, either on input or output/outcome side. Referring to section 2, inputs are considered as items which affect the delivery of the service substantially and cannot be omitted without productivity losses.

The categories are not attributable to stakeholder groups due to the fact that most studies do not represent a certain stakeholder. We account for different stakeholder perspectives in section 5. The following subsections describe the categories and single items contained therein.

4.1.1. Communication

The communication between stakeholders fosters the information exchange between those who are responsible for and / or dependent on a high-quality provision of the TMS.

Communication, especially in person-oriented fields such as medicine is a critical factor. Hereby, family support represents an input factor for patient-oriented TMS (Ryan, Kobb, Hilsen, 2003). Also, communication determinates the quality of care (Nijland et al., 2008). In the papers identified in our literature review, most of the times the communication between patient and physician could be monitored (Andersen et al., 2010). From a more general perspective, it can be assumed that existent communication lines between all stakeholders – at least in a bilateral way - might be beneficial for the overall provision of the service, e.g. between the physician and the patient's relatives (Chaudhry et al., 2007).

4.1.2. Data

The definition of TMS in section 1 already points out one of the specific attributes of these services – the use of information and communication technology. This implies the transformation of information into data at the source, which can be read and interpreted by the receiver. As TMS often deal with sensitive data, they must fulfill certain requirements concerning the data.

Hence, the evaluation of data-related input factors is an integral part of a comprehensive evaluation of a TMS.

Some of the reviewed papers name high data quality in general as a requirement (Demiris et al., 2008; Pare, Jaana, Sicotte, 2007; Konstam, Konstam, 2010), others refer more specifically to accuracy, reliability, integrity and traceability of the data (Chang, Chen, Chang, 2009; Lind et al., 2002; Romero, Cortina, Vera, 2008) or to the interoperability respectively (Bayne, Boling, 2009; Demiris et al., 2008).

Beside these requirements, which do not explicitly refer to health services, some articles mention privacy related items such as encryption and user authentication (Bellazzi et al., 2002; Lind et al., 2002) or the need for privacy policies (Demiris et al., 2008) to ensure safe and sensitive handling of private data and for the protection of individual privacy.

4.1.3. Financials

The analysis of financial input factors is crucial for the economic success of telemedicine applications. Still, only a few papers deal with financial-related items. Articles considering these input factors mainly point out the initial capital expenditure for hardware and software (Bayne, Boling, 2009; Demiris et al., 2008; Romero, Cortina, Vera, 2008; Roth et al., 2006). This includes expenditures for monitoring devices possibly needed at patients home and investments in the IT-infrastructure of the health care provider. Other items considered are the operating expenses of TMS. These items mainly refer to expenses for the software operation and maintenance and for the provision of technical support to patients and health care providers, i.e. mainly personnel expenses (Pare, Jaana, Sicotte, 2007). Costs for the transmission of data were not included in any article. This might be due to the very low marginal cost of data transmission.

Another input item of telemedicine applications are the reimbursement terms, which determine the possible financial outputs for the health care provider (Louis et al., 2003; Smith et al., 2008). As these terms are highly dependent on the legal policies of a country and are often subject to negotiations between insurance companies and physicians, this topic is regularly not addressed in the current body of literature.

The analysis of initial investments, operating expenses and possible returns can be used as a basis for an upfront break-even analysis. We found articles in which the authors described the service from a business model perspective (Bayne, Boling, 2009; Varshney, 2007). However, such an analysis is only very rarely conducted.

The literature review revealed that a comprehensive analysis of the financial input factors was not conducted.

4.1.4. (IT) Infrastructure

By definition, TMS consist of an IT part. Thus, the IT infrastructure, e.g. devices, networks, software and servers are vital for the provision of TMS. The analyzed body of knowledge thereby mentions various IT elements. Network infrastructure and internet connectivity is found to be important (Varshney, 2007). Also, the availability of certain technologies or hardware are mentioned, e.g. two way audio video connectivity or personal computers (Nijland et al., 2008). Especially for mobile solutions in the telemedicine sector, input factors such as the wireless infrastructure or the mobile device itself (Varshney, 2007) are examined. There are also papers that have their focus on decision support (Nijland et al., 2008). In this context, it is important to consider the legislation of the according country as there are enormous differences on the trade-off between a high level of decision-support and a high level of patient security through physician responsibility.

4.1.5. Organizational (Intervention) Management

Telemedicine applications require changes in the common organizational structure of health care providers. On the one hand, the personnel of the health care provider must be educated concerning the routine handling of TMS and according technical support must be implemented. TMS can have an impact on the relationship and communication between the patient and health care professionals (see categories “communication”, “teaching / education” or “personal skills and attitudes” respectively) in terms of frequency and type of communication as well as data and diagnosis transparency. To cope with these issues, a transition to more flexible organization of the intervention might be necessary. On the other hand, TMS offer new possibilities in the entire intervention management (Hauptman et al., 2008) due to a closer integration of the patient and the increased amount of diagnosis-related data. This includes the possibilities to implement a system-based knowledge management (Nicolini, 2006). Knowledge management approaches can be used to integrate patient data from different sources, either measured by the patient at home or through data gathered during hospitalization or physician visits. This can include vital data as well as information about medication. The analysis of these data can support the alignment of several simultaneous interventions and improve the quality care, e.g. a cardiologist can align the medication against heart failure to the medication of the general practitioner against high blood pressure.

Furthermore, telemedicine enables adjustments of the intervention scheme without the necessity that the patient has to visit the physician, e.g. the adjustment of medication via telephone on basis of telemetric transmitted data, or to plan an intervention, e.g. if the physician recognizes early signs of decompensation, the respective intervention can be planned.

Another organizational input factor which has to be considered for certain application is the possibility for self-management by the patient (Gomez et al., 2002). For example, diabetes patients can measure their blood glucose level and inject the required insulin dose themselves. A server-based application allows the patient to easily analyze historical and current data while giving the doctor the opportunity to monitor the intervention concurrently.

Also, it is crucial to implement quality assurance processes in order to maintain a high level of service quality (Hauptman et al., 2008).

4.1.6. Personal Skills and Attitudes

The provision of TMS is dependent on personal skills and attitudes of the stakeholders involved. This includes all personal prerequisites which are necessary to use TMS and are not subject to special training and education processes as well as items relating to the individual mindset of the involved people. If the TMS requires actions of the patient to conduct the service properly, compliant patients are needed (Bobrie et al., 2007). Another important prerequisite for effective TMS are the perceptions of the patient regarding the impact on their privacy (Or, Karsh, 2009) along with trust in the service (Essén, 2008).

Since the role of the patient usually changes with the use of telemedical application to a more active role (Andersen et al., 2010), the patient needs to be capable of using the devices or to elevate the needed information. Therefore, depending on the technology at least some computer skills might be necessary (Or, Karsh, 2009).

But not only is the patient subject to changes. TMS also requires some flexibility of the health care professionals in regards to communication with the patient and other health care professionals (MacFarlane 2006). The physical absence of the patient during the intervention process requires flexible methods to contact the patient in order to receive important information about patients' self-assessment (Andersen et al., 2010). To measure the health status of the patient, clinic and ER visits within the year prior to enrollment are captured. Also, bodily pain might be asked for (Ryan, Kobb, Hilsen, 2003). Such information might be acquired through the use of a patient interview or forms that have to be filled out before the actual treatment. The literature review also mentions the ability and willingness to use technologies as an input factor (Ryan, Kobb, Hilsen, 2003).

4.1.7. Time Effort

The process time is one of the key factors affecting the productivity of the process. In the context of TMS, the time effort may not solely relate to the process time, e.g. the time of the entire intervention as a relevant factor (Bayne, Boling, 2009; Havranek, 2005), but also to the time effort contributed by different stakeholders. For a physician, the frequency and mean time of home visits defines the time effort (Edwardson, 2007; Romero, Cortina, Vera, 2008), while for the patient the time needed to provide the data can be the relevant time measure.

4.1.8. Training / Education

Depending on the complexity of the TMS, various kinds of trainings are necessary before the device or service can be used. The items allocated to this category aim to enable structured education relating to the specific TMS. These items include teaching processes as well as teaching material or user guidelines for a specific TMS. For some applications a written guideline is sufficient. But especially for doc2patient-solutions a more detailed training needs to be provided before start. The quality of the training was found an important issue to be examined since the patient might handle the hardware of the TMS at home on her own, but accurately needs to survey and transmit the right data at the required time (Demiris et al., 2008).

In addition to the training regarding the application some devices require a diagnosis-related training. The patient needs more specific information about the disease to send the correct information (Balk et al., 2008).

But also the physicians have to be trained before they could use the application efficiently. We found that in the most examined applications the training was necessary only at the start and that these costs could be regarded as fixed implementation costs (Hebert et al., 2004; Jansà et al., 2006).

4.1.9. Usability

Usability aspects play a critical role for TMS and relate mainly to the software and hardware used in the IT-part of the TMS, e.g. devices or information systems. This aspect applies to both, the frontend and the backend part, i.e. for the case of a telemonitoring service it encompasses the patient dealing with the device and the physician dealing with the software that displays the data which has been transferred from the device to a central data access point. To design feasible TMS, technical problems such as transmission or monitor failures have to be minimized. Additional communication paths between physicians and patients must be in place to contact the patient for the case of missing data or if the patient has complaints or symptoms that the TMS does not transmit (Willems et al., 2007). In any case, the ease of access to the data by the physicians is to be guaranteed to ensure effective use of TMS (Nicolini, 2006).

User friendliness is mentioned as well (Nijland et al., 2008). In this context, the friendliness is meant to be based on a design which fits the user's needs – no matter whether the user is a patient, a relative, a physician or any other stakeholder.

4.2. Output / Outcome Factors

Analogous to section 4.1 we clustered all output/outcome items into categories. Some categories refer to the same topic as some input categories, but contain different items. With regard to our understanding of productivity, the output and outcome factors include the benefits of TMS compared to alternative treatment as our review shows that this is regularly presented as outcome of TMS. We have identified seven output / outcome categories, which are described in the following subsections.

4.2.1. Acceptance

Usually, both sender and receiver of the information of telemedical devices and services have to put some kind of effort into the process. Therefore, to accomplish the full effectiveness these services and devices have to be accepted by all user groups. Generally, two kinds of TMS were identified: doc-2-doc and doc-2-patient. Doc-2-doc applications are used for the communication between professionals only while doc-2-patient applications are used for information exchange between professionals and the patient. While most studies that analyzed the issue of acceptance focused on the patient or the physician, other stakeholders such as nurses or relatives were studied as well (Mair et al., 2005; Waterman et al., 2001).

Since the acceptance of a telemedical device or service is complex psychological process we found studies that only focused on parameters that usually lead to acceptance. These were the patient's trust in the device, personal utility such as saving time or a higher quality of treatment, and raised satisfaction rates. Satisfaction plays a significant role for the acceptance of a TMS. This is not limited to patient satisfaction, but also includes physician satisfaction (Beaver et al., 2009; Bunn, Byrne, S., 2005; Lewis et al., 2010), nurse satisfaction (Ryan, Kobb, Hilsen, 2003), employee satisfaction (Whitten et al., 2008), etc. This is also valid for the positive attitude towards TMS (Kaldoudi, Chatzopoulou, Vargemezis, 2009). Overall, the patient's trust in the service is presented as relevant outcome (Whitten et al., 2008). Reduction of both, the time needed per treatment (Matheus, Ribeiro, 2009) and the frequency of treatments (Goldschmidt, 2005), is to be monitored. In this context, the reduction of office visits, e.g. to receive test results, represents another identified factor (Goldschmidt, 2005).

4.2.2. Communication

Communication between the stakeholders are vital and provide major chances for sustainable improvement of the service itself on the one side, but also of the understanding about the disease or illness and its according treatment on the other side. These communication outputs and outcomes of the TMS provision can be manifold. Of special consideration were the comparison of face-to-face and remote (physical examination/care) communication. Improvements of the communication of care givers and patients can be the result of increased satisfaction and acceptance of TMS (Cheng, Montalto, Leff, 2009). The suggestions for improvement by patients as well as the improved communication among health professionals (in doc-2-doc TMS) were seen as potential benefits. A more flexible communication can lead to a reduction of waiting time as scheduled visits may become unnecessary and second opinion can be obtained easier (Romero, Cortina, Vera, 2008).

4.2.3. Data

We have already addressed the importance of data related input factors. The data itself generated through the service delivery process can be understood as an output of the service. However, our review revealed that most evaluations concentrate on outcomes of the services. Data as output factor was named only seldom. Items appeared in some papers related to the amount of data (Gomez et al., 2002; Pinna et al., 2007) or frequency of transmission (Pare, Jaana, Sicotte, 2007).

To assess the quality of TMS some studies did not concentrate on the amount of data but analyzed the strength of agreement between data from traditional face-to face communication and the data of TMS. In cases where TMS were not able to deliver the needed data, it could not replace the direct contact (Hill et al., 2009; Botsis, Hartvigsen, 2008).

4.2.4. Financials

Financial benefits might occur for all involved stakeholders. Our literature review shows that financial benefits are often considered in the evaluations. The reported benefits range from the measurement of certain direct costs related to the intervention up to indirect benefits as an increased economic welfare. Several articles referred to the direct cost of an intervention (Chaudhry et al., 2007; Demiris et al., 2008; Kashem et al., 2008; Krumholz et al., 2002) or to overall costs of the service (MacFarlane, Murphy, Clerkin, 2006; Mallick, Kanthety, Rahman, 2009) and subsequently to the cost-effectiveness of an intervention (Dorman, 2001; Hailey, Ohinmaa, Roine, 2004) as an important outcome of their evaluation. However, in most cases there is no explicit explanation what these cost items comprise and how they were measured. We found neither a study that included a detailed comprehensive financial model for the entire service involving all relevant stakeholders nor one which took a clear stakeholder perspective. Traditional performance measures such as return on investments are rarely considered.

Due to TMS the whole treatment can be changed over time. Therefore, fundamental parts of the traditional treatment can become unnecessary. As soon as complete process steps, e.g. an emergency visit, become obsolete, the society saves the costs of that step. Especially health economic evaluations assess these savings with their monetary value for the society and the health insurances, respectively. One of these benefits of telehealth services was analyzed quite often in the studies. This benefit relates to the reduction of hospital stays, either measured as total number of readmissions (Jerant, Azari, Nesbitt, 2001; Riegel et al., 2006), the mean duration of a hospital stay (Balk et al., 2008) or as total days spent in hospital (Trappenburg et al., 2008; Botsis, Hartvigsen, 2008; Azarmina, Wallace, 2005). Although not directly measured in monetary terms, these items can be linked to financial measures. The generated benefit depends on the stakeholder perspective. A reduction of total hospital readmission indicates savings for the insurance company, while a reduction of the mean duration of one hospital stay in most cases leads to savings for the hospital operator. From society perspective, an avoided hospital stay can reduce the time a patient is absent from work indicating a higher total productivity.

The literature shows a variety of other financial measures, which have been interpreted in comparison to usual care and for the respective stakeholder. Benefits for the health care provider named in the articles were the impact on staffing cost (Roth et al., 2006) and reduction of time per intervention implying lower costs per patient (Azarmina, Wallace, 2005; Masella et al., 2008; Chumbler et al., 2007). Patient related benefits refer to travel costs (MacFarlane, 2006/ Biermann, 2000/ Jansa, 2006) - if not reimbursed by the insurance company - and the avoidance of absence from work (Jansà et al., 2006; Romero, Cortina, Vera, 2008; Oakley et al., 2000). Insurance companies can benefit from telemedicine directly by reduced cost of drugs (Mallick, Kanthety, Rahman, 2009; McManus et al., 2009; Pinnock H, 2005), e.g. in blood pressure home monitoring due to the improved information about symptoms, or indirectly by the reduction of medical errors or avoidance of emergency readmissions, e.g. if early signs of decompensation can be detected.

4.2.5. Health-related Quality of Life

Next to health itself the health-related quality of life (HRQoL) is one of the most important outcomes for the stakeholder patient. HRQoL usually includes physical and mental health perceptions and their correlates—including health risks and conditions, functional status, social support, and socioeconomic status (Fayers, Machin, 2007). Especially in the health economic evaluations of telemedicine application the HRQoL was usually reviewed. Here, generic as well as indication-specific instruments such as questionnaires were used in order to get relevant information for the evaluation of indications (Saxon et al., 2007; Trappenburg et al., 2008; Willems et al., 2007). Nevertheless, the term HRQoL was often used in different ways and instruments that measured the satisfaction of the user were misleadingly called HRQoL-instruments.

Since the reviewed articles all examined telemedical applications but used a wide spectrum of measurement instruments one can conclude that maybe a specific instrument for telemedicine is required.

4.2.6. Health Status

Besides financial aspects telemedicine applications can improve the treatment and lead to a better health status. The use of these applications has to maintain at least the same health as the traditional treatment. Therefore especially the health economic studies concentrated on medical aspects and improvements regarding the health of the participating patients and compared these with the financial impact of the application. The examined end points vary depending on the indication in which the device or service is supposed to be used. But we could identify some common objects like symptom-free days (Jongste et al., 2009), reduction of mortality (Inglis et al., 2010; Riegel et al., 2006; Saxon et al., 2007), total days alive and out of hospital (Balk et al., 2008; Dar et al., 2009; Jung et al., 2008), or the reduction of the number of emergency department visits (Trappenburg et al., 2008).

We found that most studies had in common that they could not present a financial valuation for the improved medical end points. Therefore, the results of these studies were only comparable within the same indication.

4.2.7. Personal Skills and Attitudes

Even though basic skills and knowledge about the application and the disease are required to maintain the service (as we observed above), we found literature that showed improvements in this field after using the application. For example patients learned how to handle their disease in a more efficient way (Balk et al., 2008; Botsis, Hartvigsen, 2008). One issue that was found to be frequently dealt with was the increased self-efficacy of patients that used TMS. The patients felt more secure dealing with their disease, e.g. the control of a diabetic’s blood sugar level, and felt more personal freedom and mobility since they knew that their physicians had more information about their health status (Dale et al., 2009; Dougherty, Thompson, Lewis, 2005).

5. Allocation to Stakeholders

The telemedicine sector is characterized by its heterogeneous stakeholders, namely: patients and their relatives, clinicians, practitioners in private practice, nurses and other clinical or care personnel, hospitals, IT professionals and IT service providers and health insurance companies.

In this section, we present the factors identified in our literature research and assess their relevance for the stakeholders of the telemedicine sector. Therefore, we use a trivalent scale (0, +, ++) with the following semantics: 0 stands for no relevance, while + represents some relevance for the stakeholder, and ++ marks a highly relevant factor. This relevance assessment is displayed in Table 1 below. The following subsections deal with one dedicated stakeholder each for which we outline identified input and output / outcome factors.

Stakeholder	Patients	Physicians	Hospitals	IT service providers	Health in-surances
Input factors					
Communication	++	++	+	0	0
Data	+	+	+	++	0
Financials	0[HM1]/++[HM2]	++	++	0	+[HM1]/0[HM2]
(IT) infrastruc-ture	0	+	+	++	0
Organizational management	+	+	++	0	0
Personal skills & attitudes	++	++	0	0	0
Time effort	++	++	+	0	0
Training / edu-cation	++[R]	++ [R]	0	++[P]	0
Usability	++ [R]	++ [R]	0	++ [R]	0
Output / outcome factors					
Acceptance	++	++	0	0	0
Communication	++	++	+	0	0
Data					
Financials	+	++[C]/0[PP]	++	++	++
Health-related quality of life	++	0	0	0	0
Health status	++	++	+	0	0
Personal skills & attitudes	++	++	0	0	

Abbreviations:

HM1/HM2: for TMS in the primary / secondary health market
R: representing the TMS recipient
P: representing the TMS provider
C: clinician
PP: physician in private practice

Table 1: Input and Output / Outcome Factor Relevance according to Stakeholders

5.1. Patients

Many productivity factors are related to the stakeholder group of patients. Here, usability aspects, e.g. in regards to the device, play a major role in order to reduce the complexity the patient is confronted with. This is also reflected in the trust towards TMS and their components, no matter whether they are personal or technical. The patient's communication with the physician about the treatment or with relatives for psychological support, etc. is supposed to affect the TMS provision. If it comes to decisions about the treatment, children and elderly people are often supported by their relatives. For all patients, the experiences made before - personally or by relatives - might affect the TMS provision. This holds also true for a patient's general willingness to use TMS. For cases in which the patient functions as data collector, their ability to perform this task in a sufficient manner is critical. As output factors, the satisfaction rates, service acceptance and trust of the patient regarding the TMS is mentioned as well as the - hopefully positive - change of her health status.

5.2. Physicians and Clinical / Care Personnel

Beside the patients, the health care providers, e.g. the physician, nurse or other care givers, are directly involved in the execution of TMS and have to cope with changes in the daily routine due to the use of TMS. Hence, most of the identified input and output items pertain to these stakeholders. For physicians in private practice, especially the financial dimension of TMS compared to alternative treatments is of great interest as they may have to invest into new hard- or software to apply the service, while the reimbursement is sometimes unclear. In Germany for example, the reimbursement of some TMS is possible, but subject to negotiations between the health care provider and the insurance company, while the preferences and objectives of these parties are not necessarily congruent. The analyzed studies revealed the importance of the health care professionals' acceptance and satisfaction with the TMS for an effective use of TMS. Satisfaction and acceptance are affected by the usability of the TMS (see section 4.1.9) and impact on the doctor-patient (or doctor-family) relationship. In the context of productivity measurement these soft factors have to be considered and balanced against hard factors as costs or time. Furthermore, TMS can affect the individual time for the physicians and nurse that is needed for the treatment. If the application can lead to more free time or time that could be used for the core competence of the user it leads to more job satisfaction.

5.3. Hospitals

In this context we understand hospitals as institutions in which physicians and other care personnel work to treat hospitalized patients. We noticed that the needs of the individual physician (see section 5.2) can differ from the requirements and strategic or economic goals of the hospital as an institution. The analyzed studies showed several benefits of TMS which are related to the hospitalization of the patient. But the beneficiary in these cases is not necessarily the hospital. The hospital can only realize savings if the use of TMS reduces the inpatient days and the intervention is paid on lump-sum basis, i.e. the hospitals get a diagnosis related fixed reimbursement per treatment; regardless of the individual effort. A reduction of total hospital readmission can lead to lower revenues for the hospital, if the readmission would have been paid otherwise. The incentive structure for hospitals often does not account for the quality of life of the patients or quality related items. Beside changes in hospitalization, which are medically induced, process improvements due to the use of TMS, e.g. process time reduction attributable to better internal communication, can increase the effectiveness of the treatment process. TMS can contribute to increased planning assurance through the avoidance of emergency visits, e.g. for telemonitoring of patients with an implemented defibrillator and subsequently to reduced staffing effort. However, TMS require specialized education of physicians and nurses and offer opportunities for a differentiation among hospital operators.

5.4. IT Service Providers

IT service providers of TMS are needed to have a high level of process and environment awareness in the very specific field of telemedicine. They need to meet the challenges of high data security requirements. Also, they should regard usability as an important factor and are supposed to build highly reliable solutions, e.g. for stroke units. This also means the ability to choose the appropriate hardware and software components and the sensitive implementation of state-of-the-art technologies. TMS provision is fostered by the service provider’s qualification in designing training sessions for both doc-2-doc as well as doc-2-patient TMS. Also, the systematic integration of the patient into the service creation process is valuable.

5.5. Health Insurance Companies

In Germany, most expenditure in the healthcare system is paid by the statutory health insurance. Hence, the financial factors on both, the input side and the outcome side, are factors of interest for the insurances. To assess the costs and utility of TMS, many studies used the point of view of the health insurance instead of the society or a single stakeholder only. Medical improvements are very valuable for the insurances if they lead to a decrease in treatment expenditures. Therefore, important medical and financial outcomes are, for example the decrease of hospitalization or the reduction of drug use. Another relevant factor is the saved travel costs that would have to be reimbursed without TMS.

For the best performance of TMS many input factors are necessary that have to be paid. If the statutory health insurance is supposed to reimburse these costs, they become accordingly relevant. In some cases the TMS enable better data quality. This can increase the quality of the billing and documentation on which the payments and planning of the insurance companies are based.

6. Limitations and Future Research

As any literature review, this paper faces limitations that are due to the literature selection process. By integrating works from cross-references and by the choice of the key words, we tried to reduce the risk of missing out on relevant works. Also, the time scope of the examined TMS is the provision of the service. This clarification plays a significant role as other time scopes such as the overall treatment process of a patient or the whole life of a patient would lead to considerably different observations and results, e.g. patients experiencing longer life expectancy through the TMS treatment and thereby being exposed to higher probabilities of getting diseases in later life phases. The duration of TMS can vary from only a few minutes in teleconsultation settings to several months for telemonitoring services. The assessment of input and output factors according to their relevance for the stakeholders still needs to be refined. The suggested assessment presented in this paper can be seen as a first recommendation derived from the results of the conducted literature review.

As to future research, the specific role of the customer / patient as co-creator needs to be considered more prominently. Hereby, the important segmentation between the primary and secondary health market with the patient being the direct customer in the second health market needs to be considered as well. Also, our emphasis on stakeholder perspectives might be further developed through the examination of the stakeholders' roles in a service system (Spohrer et al., 2007). One of the biggest challenges in this regard might be the integration of stakeholders which are not existent in traditional, people-bound medical settings, but play a critical role for TMS, e.g. IT service providers.

7. Conclusion

According to Webster and Watson (2002), a contribution of a literature review is to identify critical knowledge gaps in existing research and making a chart for future research. Thus, the results we presented in this paper are a first step towards filling the research gaps as have been proposed in recent research appraisals in the field of service science, calling for development of means to better grasp and measure productivity of services (Maglio, Spohrer, 2008). In detail, we analyzed several efficiency and effectiveness studies on TMS, and extracted input and output factors. Until the best of our knowledge, no attempts for the identification of a comprehensive set of input and output factors for TMS can be found in existing literature, and a systematic consideration of all stakeholders in the telemedical context is, not adequately addressed. In order to address these gaps, we presented an overview of input and output factors. Also, we assessed these factors regarding their relevance for the stakeholders of the telemedicine sector. Our identified input and output / outcome factors can serve as a valuable starting point for a systematic consideration in future research activities and could inform a comprehensive productivity model. Our study hence fosters research activities dealing with service productivity. The next step of our research would be to integrate the identified factors in a more comprehensive productivity model for TMS. For practice, our results can help by improving the understanding on productivity issues around TMS and thus might help to bring the potentials of TMS to practice. We also hope to contribute by systematically consider all involved stakeholder of the TMS environment.

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