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Refining resource management in healthcare delivery processes: Should we look at technology changes another way?

Márton Vilmányi

University of Szeged, Faculty of Economics and Business Administration, Business Studies, Szeged, Hungary
https://orcid.org/0000-0002-7186-7125

Ágnes Réka Mátó

University of Szeged, Faculty of Economics and Business Administration, Business Studies, Szeged, Hungary
https://orcid.org/0000-0003-2294-2800

Margit Tarjányi

University of Szeged, Faculty of Economics and Business Administration, Business Studies, Szeged, Hungary
https://orcid.org/0000-0002-0085-9435

Melitta Kálmán

University of Szeged, Faculty of Economics and Business Administration, Business Studies, Szeged, Hungary
https://orcid.org/0000-0002-2080-7384

Abstract

Background: Today's health organizations are under increasing pressure to meet a range of sometimes conflicting, often divisive goals. Consequently, they need to maximize the value created for patients as an overarching goal. Value can be addressed through organizational processes managed through activities, actors and resources. Managers perceive this interaction process mainly through resource and cost dimensions. However, the extent of the change in resources, i.e. the change in value creation caused by a new technology, has not yet been investigated.

Purpose: In our study, we examine the consequences of technological alterations resulting in a change regarding resources that impact value creation. We seek to describe the change patterns in resource compositions that occur when introducing a new technology into an organizational process.

Study design/methodology/approach: We adopted a case study method with a process perspective, where we applied the Time-Driven Activity-based Costing (TDABC) framework to capture the managerial perspective on cost and resource management related to value creation. Five healthcare protocols implemented using different technologies (face-to-face and telemedicine) were analyzed.

Findings/conclusions: Resource changes due to technological modifications seemingly occurred without a distinct pattern. However, we could confirm that the changes not only affected activities in areas where new resources were introduced, but also had spillover effects. Our results reveal that the extent of changes caused by technological alterations can be determined through changes detected in information. The results highlight the importance of the extent of change and information management.

Limitations/future research: The most significant limitation to generalizing our findings is the research context itself. The sector-specific characteristics of the healthcare sector limit the generalizability of our results. Another limitation is the number of observed cases and our research method. This suggests the need for further research, as it seems justified to test the TDABC methodology on multiple other cases.

Keywords

technological change, resource management, technology change patterns, telemedicine, digital platform, Time-Driven Activity Based Cost (TDABC)

Introduction

Technological change is radically reshaping not only market behaviors, but also the way organizations operate and the interactions between actors. For a given technology, specific resources interact with each other to create value for the organization, and in combination provide utility to individuals or actors in the network (Håkansson & Waluszewski 2002; Håkansson, 2009). As technology changes, the range of resources interacting with each other changes, the way in which resources are combined, thus the utility provided by them changes simultaneously (Gressetvold 2001; Håkansson et al., 2009).

However, as technology changes, new resources are emerging in exponential numbers, and new knowledge is needed to bring them into operation and control their costs. In addition, resources are often not even managed independently, as a decision to use a resource results in the "calling up" of more and more resources, transforming the existing use of resources. In many cases, resources also change the information flows of processes and the way actors are involved (Dóra – Szalkai, 2020). Therefore, the implementation of a technology leads to numerous changes, whereby success is far from being determined (Gressetvold, 2001; Håkansson et al., 2009).

The literature has so far provided few answers to address these phenomena (Keel et al., 2017). It is not clear along which patterns technology transforms the resource constellations used for a given purpose, nor is it clear how to identify the extent of the changes that result from the development of technology. These questions are critical for value management, and for harnessing the benefits of technological change.

In our study, we examined the emergence of technology-induced change in health service organizations, where the pandemic caused by the SARS-COV-2 virus has accelerated the urgent adaptation of technological developments. There is an increased demand from patients, healthcare providers and policy makers alike for the growing adoption of telemedicine and telehealth applications (Parikh et al., 2020; Middleton et al., 2020). This also implies a transformation in the way health services provide value.

In healthcare services, value can be described as the ratio of the outcomes achieved in a health state to the inputs made to achieve them (Porter 2010, p. 2477). Value, from this perspective, can be enhanced by increasing the outcomes achieved in a health state for a given set of resources, or by minimizing the inputs in the whole healthcare delivery cycle for a given set of outcomes (Kaplan & Porter, 2011). Managing value in this way requires increased control over the resources and resource combinations involved in a given care process, and thus over the inputs. Business processes create value as a result of the interaction of activities, actors and resources (Håkansson & Snehota, 1995), so managing value is in essence managing interactions. However, managers view this management process of interactions through the management of control over resources and costs (Porter, 2010; Kaplan & Porter 2011; Kaplan et al., 2014).

To model the managerial perception and the managerial perspective in controlling expenditures, we applied the Time-driven Activity-based Costing (TDABC) (Kaplan & Anderson, 2004), a costing method widely used in healthcare service organizations. TDABC, because of its approach, has numerous benefits for healthcare organizations. TDABC directly assigns resources to activities required to achieve a given health outcome by calculating the expenditure of the care cycle based on the duration of time required to use the resources in a given activity (Kaplan et al., 2014). It can enhance value by capturing costly steps, creating opportunities to incorporate lower cost resources, or incentivizing the continued use of expensive resources (Kaplan et al., 2014).

We examined the consequences of a change in the technology used by a clinical organization providing patient care. Our focus is on how the introduction of a new technology (in this case telemedicine technology) reshapes patient care activities, resources and capacities involved. Our investigation is conducted from the analytical perspective of TDABC by examining how changes are manifested when applying the TDABC framework. Our results point to the need to identify the extent of change, the importance of information management, and the need to improve TDABC methodology.

In this article, we therefore start with an interpretation of the characteristics of technological change (Chapter 1.1), covering the main literature on the tangibility of resources, technology and resource interaction, and the key contexts in which they are understood as they change. We then turn to an explanation of the concepts of telemedicine and telehealth (Chapter 1.2), interpreting the experiences and contexts identified so far in research on patterns of change in healthcare practices supported by digital tools. Next, we present the perspective of TDABC, a framework commonly used by healthcare providers to control resources, and the cornerstones of its application (Chapter 1.3). We conclude our literature review by summarizing the findings of applying TDABC in healthcare organizations (Chapter 1.4). In the second chapter (Chapter 2), we elaborate on our research question and research methodology, and then focus on the details of our findings (Chapter 3). Following our detailed answers to the research questions (Chapter 4), we draw our main conclusions (Chapter 5) and outline the main directions for theoretical and practical application. We conclude our study by identifying the limitations of the extension of our findings and future research directions (Chapter 6).

1. Theoretical Background

1.1 Characteristics of change regarding technology and resources in interactions

Change in the life of organizations can be seen as a constant feature that is present in every aspect of organizations (Burnes, 2004). It is generally accepted that successful change management is a necessity in an ever-changing business environment, yet around 70 per cent of change efforts fail (By, 2005, p. 370), making the importance of successfully managing change even more salient. The nature of change itself, and thus the subject of organizational change, is extremely diverse, and it is not surprising that a number of studies have been carried out focusing on different aspects of organizational change (Whelan-Berry & Somerville, 2010; Weick & Quinn 1999; Pettigrew, 1985). As we focus on change processes related to specific resource bundles identified as certain kinds of technology, we seek to obtain a deeper understanding of the dynamics of change in the context of resources and the interactions between them. For our investigation, the foundations of the resource-based point of view (RBV) can serve as a starting point. The RBV is one of the most widely used theoretical perspectives today and pioneered the conceptualization of firms as sets of unique resources that form the basis of organizational value creation (Penrose, 1959). Two of the most popular theoretical approaches based on the RBV are the network approach developed by the Industrial Marketing and Purchasing Group (IMP) and the service-centric perspective known as Service-Dominant Logic (S-D-L) by Vargo and Lusch. Both approaches emphasize the key role of resources in business networks, and they assume that the dynamic and evolutionary nature of resources control value and exchange processes (Bocconcelli, et al., 2020, p. 1). Both perspectives can be also used to explore healthcare networks in depth (Dóra & Szalkai, 2020; Wells, et al., 2015). However, the two perspectives describe the nature and value of resources differently, along with the context in which resource interconnection occurs. Because our focus is on resource combinations in healthcare delivery processes, with a particular focus on technology change, we examine this phenomenon from a network perspective. The research of the IMP group, which uses the network approach, points to the complexity of combining resources, managing changes in resource combinations and intense interactions, all of which characterize the technological adaptation that takes place in healthcare organizations (Cantù, et al., 2012; Hu, et al., 2002).

From the IMP point of view, resources are considered economic entities that represent value to an economic actor (Prenkert, et al., 2019, p. 140) that become resources only when a way of using them is revealed (Gressetvold, 2001). However, due to resource heterogeneity, individual resources may be considered passive and lacking in value. Thus, the nature of a given resource and its inherent economic value-creating potential will be determined by how it interacts with other resources (Gressetvold, 2001; Håkansson et al., 2009). In addition, the characteristics, usefulness, and value of resources owned by a given organization depend not only on how they are combined with other resources within the organization but also on how they are combined with related resource combinations within networks (Håkansson et al., 2009, p. 65-66). An important finding of the IMP group is that networks strongly influence the characteristics of organizations' resources as the latter do not have full control over their resources due to interdependencies (the latter are also related to the resources of other organizations) (Prenkert et al., 2019).

Accordingly, one should evaluate resources and resource combinations relative to each other and in relation to the actors who create, activate, and use them (Cantú et al., 2012). The relationships between actors and resources can be clearly traced using the Actor-Resource-Activity (ARA) model

(Håkansson & Snehota, 1995), which describes the content of business relationships. In this, actors can be characterized by the range of activities they undertake and the set of controlled resources that are used. For resources to be combined, they must interact. During this process, they must be transformed, so they change, recombine, evolve, and can be used and reused (Crespin-Mazet, et al., 2014, p. 11). Thus, resource interaction refers to the processes of combining, recombining, and jointly developing resources (Baraldi, et al., 2012, p. 266). The channels of resource interaction processes are called resource interfaces. Interfaces specify how resources are connected (Prenkert et al., 2019, p. 139). A resource interface connects at least two resources but can indirectly connect many others through indirect interfaces (Prenkert et al., 2019, p. 142). The systematic interconnection of resources is a complex process that results in complex and unique interfaces. When changing a resource (i.e., when a new resource is involved or an existing resource is developed) new interfaces will be created that will have a spill-over effect on indirectly related resource combinations (Håkansson et al., 2009).

Different resources are connected in different ways in value creation processes by creating unique interfaces. Every change in the resource level also changes the value creation process. This is especially true for resource constellations that combine many resources that converge around a particular technology. Technology change plays a key role in the proper utilization of technology and ensuring the level of production/service (Hu et al., 2002, p. 198).

A technology is a unique system of relationships based on interdependencies between many different resource entities that can play multiple roles in exchange processes. Technology may be the subject of exchange, but it is more often involved in transforming the resources being exchanged. Håkansson and Waluszewski (2002; 2007) describe technology as resource bundles interconnected through different points of connections, namely a pattern of interfaces. This pattern of interfaces determines the characteristics of each resource element, consistent with the technology (Håkansson & Waluszewski, 2002, p. 211). Consequently, when such patterns change, it is important to understand exactly how this will affect (1) the coherence of the connections of pre-existing resources in the pattern, and (2) how the pattern fits into value-creation processes (Gressetvold, 2001).

Changing the current technology, therefore changing the way value is created leads to a number of challenges in organizations. We examined the context of healthcare organizations where, in the era of Value-based Healthcare, particular attention is being paid to the process of value creation. Exploring technological change and the impact of change on value raises particularly interesting issues, as value creation involves a complex system of resources in healthcare services, where innovative digital platforms are being used to maximize value for patient health.

1.2 Value creation and technological adaptations in healthcare

When venturing to study technological adaptations in healthcare, it is important to understand the main features of healthcare as a service system. One of these is that value creation takes place across organizational boundaries in the form of complex services, as the value perceived by stakeholders is realized as a result of the collaborative activities of vastly different actors (Frow, et al., 2016). Furthermore, organizational units are involved in producing these complex services, from hospitals through specialists offering specialized services to units that provide only basic services (Porter, 2010).

In order to successfully produce value in healthcare, the transformation of a wide variety of resources must take place through the cooperation of a diverse set of actors. Other essential features of the healthcare delivery system are related to the management of these resources. The resources to be utilized are limited, and there is strong demand for them from actors with different interests (Frow et al., 2016). Actors may have different positions and perceptions regarding the healthcare delivery system they are part of (Pauli, et al., 2023), and about the value attainable from it and the limited available resources and their utilization (Edvardsson, et al., 2011).

Based on the above, it is clear that healthcare organizations will be able to successfully maximize value only if they can adequately manage the acquisition and assembly of resources.

To maximize value and improve patient health through resource management, healthcare providers have started using more digital technologies and digital platforms (e.g. social media) (Akdaş & Cismaru, 2022). The various information technology solutions and digital platforms used in healthcare are highly effective at reducing complications in healthcare procedures and positively impact quality of life by increasing social and economic benefits (Sikandar, et al., 2022, p. 35).

However, the advancement of digital technologies in the healthcare sector has been driven not only by opportunity but also by necessity. For example, in 2020 – as a result of the onset of the coronavirus epidemic – access to face-to-face healthcare delivery became limited, resulting in an increase in the use of telemedicine (Parikh et al., 2020; Middleton et al., 2020).

Telemedicine is rather broadly interpreted. It means the use of information technology to provide location-independent healthcare services. Telemedicine applications are implemented in the hope of increasing the quality and accessibility and reducing the cost of healthcare (Paul, et al., 1999). Telemedicine has been applied in the fields of prevention and patient care, including diagnostics, medical care, and rehabilitation (Sisk & Sanders, 1998). Telemedicine applications can take the form of remote monitoring, telecommunication-assisted health consultations, and complex programs involving the complex application of innovative technologies and processes (Reardon, 2005). The concept of telemedicine has now been transformed. Telemedicine today refers to the use of telecommunications devices in healing, while all services that complement healing are described in the literature as telehealth (Puskin, et al., 2006; Schwamm, 2014). Although telemedicine is defined as the use of information technology in health services, it is always accompanied by the development of human resource systems, the redefinition of social and cultural barriers, and the development of organizational structures (LeRouge, et al., 2010).

In the digitally supported healthcare delivery process, various determinants of patient care activities and the resources that are used can be identified, such as the respective digital platform, the way information is managed, additional communication tools and resources, and staff preparedness (Middleton et al., 2020; Zanotto, et al., 2020). The use of digital platforms during the introduction of telemedicine requires the acquisition of platform-compatible devices (e.g., smartphone, platform, and computer) (Middleton et al., 2020). In many cases, the creation of individual facilities for the application of telehealth is necessary (Zanotto et al., 2020; Rodrigues, et al., 2021).

The studies that have compared the efficiency, time, and resource intensity of telemedicine and telehealth with traditional care have found that some activities change, alter, or disappear as technology changes, while in other cases, technology brings new activities to life (Parikh et al., 2020; Portney, et al., 2020; Bauer, et al., 2020; Middleton et al., 2020). Discontinued activities release reserved capacity or resources, while new activities involve new resources into the care process. The resource intensity of telemedicine and telehealth is also found to be changing. As the time activities undergo changes, so does the use of resources, and in some cases the type of resources that are required (Rodrigues et al., 2021; Parikh et al., 2020; Portney et al., 2020). Some telemedicine and telehealth activities free up time, and others lengthen the time that is taken. With some telemedicine and telehealth activities, the resources that are used change (for example, an activity once undertaken by a doctor in the case of face-to-face medicine is carried out by a nurse), modifying the cost of the care process.

1.3 Time-driven activity-based costing (TDABC) methodology and its application in healthcare

The focus of organizations' technological development and adaptation activities is on enhancing their ability to create value. When it comes to value creation, the aim of introducing a new technology is to enhance value, either by improving the outcomes that deliver value or by reducing the level of costs associated with value-creating activities. Managers meet these issues regarding value creation and technological adaptations mainly through cost analyses. Among cost analysis frameworks, various Activity-based costing (ABC) methods are often used as a tool for managerial control. A more accurate and sophisticated version of activity-based costing (ABC) is the Time-driven Activity-based Costing (TDABC) framework.

In contrast to the traditional ABC methods, when applying the TDABC method, the costs of resources are not allocated to activities and then products; instead, managers first estimate the resources required for each transaction, product, or customer. Then, two parameters must be estimated for each resource group, on the one hand, the unit cost of providing a resource, and on the other, the unit time of resource capacity use per product (Kaplan & Anderson, 2004).

TDABC is most commonly applied by healthcare organizations to healthcare systems or healthcare facilities (Etges et al., 2019; Zanotto et al., 2020; Portney et al., 2020; Rodrigues et al., 2021). The growing healthcare application of TDABC is rooted in the value-based healthcare (VBHC) framework. VBHC encourages healthcare organizations to optimize the value equation by maximizing health outcomes while reducing costs (Keel, et al., 2020).

TDABC allows providers to accurately measure the resource requirements and costs of treating patients under specific health conditions throughout the delivery cycle (Kaplan et al., 2014; Cidav et al., 2021). Institutions often use the method to explore opportunities for the development of the delivery cycle, to assess the costs of the healthcare process, to improve information about costs, and to compare traditional and time-based cost information (Etges et al.,2020a; Etges et al., 2020b). Frequent operational applications include redeployment, workflow development, and the modification of the use of facilities (Popat & Guzman, 2018; Etges et al., 2022).

The healthcare application of TDABC is described by Kaplan and Porter (2011) as a seven-step process, although based on practical experience Etges et al. (2019) define eight steps. Experience has shown that critical steps in the application of TDABC are: (1) the definition of study objectives, (2) the identification of medical conditions, (3) the definition of the care delivery value chain (CDVC), (4) the mapping of processes, identification of resources and capacities involved in processes, (5) the estimation of resource and capacity times required by processes, (6) the estimation of costs of resources and capacities (direct and indirect), (7) the definition of capacity cost rate, (8) the cost estimation of care processes, (9) cost-data analytics, and (10) support for management decision-making (Allin, et al., 2020; Choudhery, et al., 2021; Etges et al., 2019; Etges et al., 2020a; Kaplan & Porter, 2011; Kaplan et al., 2014; Keel et al., 2017; Pathak, et al., 2019).

TDABC works well when applied to standardized protocols through which services are provided in a repeatable manner. Based on this, the healthcare delivery process can be defined and mapped (Keel et al., 2020). This is an important issue, as an essential element of health-tailored TDABC is defining CDVC, through which activities are described from the beginning to the end of the delivery cycle (Keel et al., 2020; Thaker, et al., 2017). This step includes identifying activities, locating them, mapping the whole care process, and helping to identify the resources and measurements that are needed. The step is thus associated with a myriad of benefits; however, few studies have addressed the location of the care process, methods of measurement, the flow of information, and the involvement of patients (Keel et al., 2017). This requires an examination of care activities, the related resources and capacities, and the interactions of patients who are involved.

During the application of TDABC, the issue of incorporating alternative (non-standard) activities into the care process model arises. Alternative activities may be due to specific complications or differences between patient groups. These activities happen separately (without affecting the occurrence of other activities). As a result of their occurrence, the utilization time of existing resources either increases or their realization requires the use of additional capacities and resources (Sadri, et al., 2021; Fang, et al., 2021).

Using TDABC allows organizations to manage the implementation of specific activities with different resources. For example, a different resource can change the capacity that is used in a given activity, raw material, the learning curve, or needed competencies (Thaker et al., 2017). In this regard, the TDABC method focuses on learning. According to the TDABC methodology, if the analyst identifies a change in the cost of the resource or the practical capacity of the required resources, the resource cost per time unit or the capacity cost rate should be updated. Through this, a given activity can be easily updated, along with the cost estimate of the whole process (Kaplan & Anderson, 2004).

However, the baseline method does not take into account interaction between resources in the case of new or changed resources, the modification of activities, and the consequent spill-over effects that may be caused by technological change. Experience has shown that the use of a new resource (capacity) can affect other resources. For example, using a new device can affect lead time and information flow, thus capacity utilization. In addition, the use of a new capacity may justify additional new activities, requiring new resources (Bodar, et al., 2020; Basto, et al., 2019).

Some studies that focus on technology change do not take into account the spill-over effects of technology change, nor do they address how technology change alters the resource or capacity requirements of activities not directly affected. Other studies (Kukreja, et al., 2021) suggest that the technological modification of one activity in the care process affects the nature and/or timing, and therefore the cost, of further activities.

Examining the cost management effectiveness of telemedicine-supported care processes compared to traditional care processes is a current and increasingly studied question (Garoon, et al., 2018; Bauer et al., 2020; Parikh et al., 2020; Rodrigues et al., 2021). Researchers have used the TDABC method to examine changes in activities and their cost implications to compare telemedicine and the telehealth process to face-to-face healthcare protocols. However, changes in resources and interactions between new technology and resources have not yet been examined.

2. Method

The original aim of our research was to study the managerial point of view regarding organizational change by detecting business interactions occurring during technological adaptations in healthcare organizations. To capture the managerial point of view related to business interactions impacting value creation in healthcare delivery processes, we applied the research dimensions of the TDABC framework in our research design. Along the TDABC dimensions, changes in business interactions in organizational processes can be well explored, as managers encounter changes in value creation brought about by technological changes primarily through cost and resource management.

However, during our initial data collection, we observed that technological change caused changes in various steps and resources in the healthcare process at numerous points, seemingly without pattern. Some protocols were radically changed, while for others only a single change could be identified. Following this initial experience, we modified our research objective to focus on the impact of technological changes on resource composition and the intensity of resource use in healthcare delivery processes.

Among our other analyses (Dóra, et al., 2022), the present study seeks to identify what patterns are identified with the impact of technological change on resource sets that are used, and the intensity of use. Based on our literature review, and, as previously emphasized, there is a research gap in this area. TDABC methodology suggests calculating capacity cost rates and estimating the intensity of use when a new resource is implemented into a process (Kaplan & Anderson, 2004). However, if spillover effects of the change are assumed, the need to re-model the whole process arises (Ostrenga, et al., 1992). However, the TDABC method does not help specify the extent to which remodeling of the healthcare delivery process might be justified (Basto et al., 2019; Bodar et al., 2020; Kukreja et al., 2021). The central question of our research is thus how to identify the extent of change(s) in resources caused by a modification in technology. How can the extent of this change be identified and modeled?

We adopted a process perspective – an approach quite often applied in parallel with qualitative case studies (Langley, 1999; Van de Ven & Huber, 1990; Bizzi & Langley, 2012). Although there are different interpretations of processes in the literature (Van de Ven, 1992), our starting point was Pettigrew's (1997) definition of a process as a series of individual or collective events, actions, or activities that take shape over time in a given context. We analyzed and compared healthcare protocols as processes implemented through different technologies (face-to-face and telemedicine) that served the same healthcare delivery process goal. The methodological application of a case study with a process perspective (Langley, 1999; Pettigrew, 1997) is appropriate for comparing healthcare protocols implemented in parallel using different technologies and identifying distinctive patterns in the former.

In line with the above-mentioned methodological approaches, we systematically analyzed five patient routes implemented through face-to-face medicine and telemedicine technologies. They include diagnosis and therapy assessment of ear, nose and throat diseases (Case ENT), application of peritoneal dialysis (Case DIAL), risk reduction for patients with metabolic syndrome (Case METSY), strengthening daily physical activity in patients with peripheral artery disease (Case PERIPHART), and monitoring of patients with heart failure (Case CARDIO).

The study was conducted at the University of Szeged, Albert Szent-Györgyi Medical and Pharmaceutical Centre between October 1, 2020 and June 30, 2021. The cases had business-to-business-to-customer characteristics. From a healthcare delivery process perspective, value was created as a result of the interaction between four types of actors associated with the studied protocols. The former were the patients and the clinical departments involved in patient care. Also involved were the actors who provided the IT infrastructure for patient care (T-Systems

Magyarország Zrt., related to e-MedSolution - MedSol, and the National Healthcare Service Center in connection with the National eHealth Infrastructure) and, in the case of telemedicine protocols, the operator of the system that provides the IT infrastructure for patient care. The observed processes were analyzed according to the TDABC framework commonly used to study healthcare delivery process changes. The TDABC framework was well suited to the study objective, as the approach requires detailed exploration of the service process, detailed identification of the resources and capacities involved in the service, and an estimation of the intensity of use (utilization time) of resources (Kaplan & Anderson, 2004). Although the healthcare adaptation of the TDABC method is specific at some points, the mapping of processes, the identification of the resources involved, and the estimation of required capacity times remain central steps (Kaplan & Porter 2011; Kaplan et al., 2014; Keel et al., 2017; Etges et al., 2019). Accordingly, the TDABC framework was appropriate for our investigation as it does not require an analysis of the unit costs of resources (direct and indirect) or the total costs of processes.

The research was carried out in three steps. First, process maps of the observed protocols (those implemented with face-to-face and telemedicine technology) were compiled using document analysis. This included the baseline recording of the activities associated with a given healthcare protocol carried out through face-to-face and telemedicine technology simultaneously in accordance with the TDABC methodology. Subsequently, we examined the resources involved for each activity associated with both of the technologies, distinguishing between human and other tangible and intangible resources. When considering human resources (H), we distinguished between patients involved in the process and medical (H1), nursing (H2), auxiliary (H3), and managerial staff (H4) (Ley, 1991; Byrnes & Valdmanis, 1993; Lopez-Valcarcel & Perez, 1996; Maniadakis & Thanassoulis, 2000; Farmer, et al., 2014). In terms of the additional resources directly used for the activities, we distinguished three types: raw materials (inputs) (A1-A4), medical equipment/tools and facilities (F1-F6), and input and output information (I / O) (input and output data transmitted through input and output information systems).

Second, we conducted in-depth interviews with senior specialists responsible for the observed healthcare delivery processes in order to confirm and refine the data collected in the first step. In addition, based on the TDABC methodology, a financial controller responsible for the observed protocols and a program manager responsible for the pilot program were involved in the evaluation and refinement of the data. With this step, the aim was to gather additional information about the experience of introducing new technology and changes in activities and resources.

Third, the content of the interviews was coded for transparency and comparability to identify systematic patterns. This method of data processing allowed us to identify, besides the (initial) activities in face-to-face patient care, the number of actors (H), facilities (F), raw materials (A), input (I) and output (O) information (data and information systems) and the intensity of resource use for each activity. This latter information is indicated by the time needed to complete a given activity. Here, based on Kaplan et al. (2014), we assumed that inputs are used in line with a given activity, and additional resources are consumed over the entire duration of the latter. The focus was on the change in activities and resource quantities and the change in intensity of use that occurred in parallel with the change in technology. Changes identified in a given protocol are highlighted in different shades of gray (see Table 1-5). If a new activity, new actor, new resource or new information has been added to the protocol, it is marked in light gray. If the change occurred in the opposite direction, i.e. the number of activities, actors, resources, information or time used decreased, these changes were highlighted in dark gray.

The processing of the data, as described above, facilitates the analysis of the quantitative and qualitative changes in the structure of each healthcare delivery process and the types of resources used as a result of changes in technology. In the following chapter, we summarize our findings regarding the case studies and illustrate the results using the analytical framework applied in the third step.

3. Results

3.1 Diagnosis and therapy of ear, nose and throat diseases (Case ENT)

The telemedicine support of the healthcare delivery process for diagnosing and treating ear, nose and throat diseases includes the introduction of otoscopic imaging and the installation of telemedicine software for transmitting and analyzing clinical data (Table 1).

In the original face-to-face healthcare process, a patient meets a specialist and an administrator in the outpatient room after checking in at the outpatient clinic (Act. 1) and is waiting for a short time in the waiting room (Act. 2). The entire healthcare process takes place in the outpatient clinic with the participation of these three actors. In the course of the treatment, using the computer software available in the outpatient room, a specialist first records patient's medical history with the assistance of an administrator while interacting with a patient (Act. 3). Then, with the help of specialized equipment available in the outpatient department, a specialist makes a diagnosis (Act. 4), on the basis of which an ICD (International Statistical Classification of Diseases and Related Health Problem) code is determined (Act. 5). Last, a suggestion for therapy (Act. 6) is proposed by a specialist.

Developers have transformed the activities of the healthcare delivery process by introducing and implementing two new resources (an otoscope and telemedicine software) into the telemedicine healthcare process. Following check-in at the outpatient clinic (Act. 1) and waiting in the waiting room (Act. 2), the process of care has been modified. First, the possibility of a patient participating in the telemedicine protocol is examined (Act. 3.1) and a patient is informed about the characteristics of the telemedicine protocol (Act. 3.2). Then comes the identification of patients in the telemedicine system (Act. 3.3) and the recording of their medical history (Act. 3.4). The steps in the telemedicine healthcare delivery process reflect the initial intended change. An otoscopic image is taken of a patient (Act. 4.1), which is evaluated and diagnosed remotely by an ENT specialist (Act. 4.2). As in the case of the face-to-face protocol, the telemedicine healthcare process is also concluded by a specialist choosing an ICD code (Act. 5) and proposing a therapy based on the diagnosis and the latter code (Act. 6).

While the role and use of administrative staff, materials and equipment, and infrastructure remain unchanged during the first two activities, radical changes are observed from the third activity onwards. In the case of the telemedicine protocol, during the latter the number of medical staff who are involved changes (the presence of a general practitioner is sufficient, instead of a specialist), as does the extent of equipment use (no examination chairs and examination desks are used). The sets of data generated by the third activity and the information systems they are coded into also change. New data emerge related to the patient's willingness to undergo treatment and the identification of the patient in the telemedicine system, and the telemedicine system itself qualifies as a new information system. Changes in the fourth activity also extend beyond changes in activities; first, the set of human resources that is involved changes radically. A general practitioner replaces a specialist when preparing for admission, while the supporting role of an assistant in the assessment of the otoscopic images is eliminated. In terms of equipment, some of the equipment formerly deployed in the outpatient room (outpatient room facilities, basic ear, nose and throat tray set) is no longer required under the telemedicine protocol. In contrast, new equipment (otoscopic camera, computer used for analysis) is introduced. Likewise, the role of disposable equipment for examination is no longer relevant due to the use of recording and analysis by the otoscope; moreover, the outpatient room is not used during the diagnosis. However, the medical room emerges as a new resource compared to the face-to-face protocol. In the case of the former, the video file shared by the telemedicine system and the diagnosis shared within the telemedicine system are identified as additional data. During the final (fifth and sixth) activities of the protocol, although the activities did not change in principle, the resources that were used did. The supporting role of the assistant disappeared, but the online IT equipment used by the specialist emerges as an additional necessary resource. For these activities, the role of the equipment used in the outpatient room (examination chair, examination table) and disposable equipment (paper, pen, mask) is eliminated, as the location, where the activities are undertaken, changes (in the medical room instead of the outpatient room). For the final activities, there is no change in the required or generated datasets, but the telemedicine system emerges as a new data information system, in addition to the traditionally used healthcare information system.

Table 1 Changes in the protocol ‘Diagnosis and therapy of ear, nose and throat diseases’ due to technological change

							F2	F5		
							H1	F2		
							A4	A4		
							A4	A4		
							A4	A4	F5	F5
			H1	H1	H1	H1	A4	A4	F2	F2
			A4	A4	A4	A4	A4	A4	A4	A4
			A4	A4	A4	A4	A4	A4	A4	A4
			A4	A4	A4	A4	A4	A4	A4	A4
			A4	A4	A4	A4	A4	A4	A4	A4
			A4	A4	A4	A4	A4	A4	A4	A4
			A4	A4	A4	A4	A2	A2	A4	A4
			A4	A4	A4	A4	A2	A2	A4	A4
			A4	A4	A4	A4	F5	F5	A4	A4
			A4	A4	A4	A4	F4	F4	A4	A4
			F5	F5	F5	F5	F4	F4	F5	F5
	A4		F4	F4	F4	F4	F4	F4	F4	F4
	A4		F4	F4	F4	F4	F4	F4	F4	F4
	A4		F4	F4	F4	F4	F4	F4	F4	F4
	A4		F4	F4	F4	F4	F4	F4	F4	F4
	F5		F4	F4	F4	F4	F3	F3	F4	F4
	F5		F4	F4	F4	F4	F3	F3	F4	F4
	F4		F3	F3	F3	F3	F1	F1	F3	F3
	F4	F5	F3	F3	F3	F3	F1	F1	F3	F3
	F4	F5	H3	H3	H3	H3	H3	H3	H3	H3
	H3	F4	H1	H1	H1	H1	H1	H1	H1	H1
Activities	**1**	**2**	**3.1**	**3.2**	**3.3**	**3.4**	**4.1**	**4.2**	**5**	**6**
Time	5	60	15		5		3	5		
Data			O	I / O	O		I / O			
Inf. system			O	I / O	I / O	I / O	I / O	O	I / O	I / O

Source: the authors' compilation

Analysis of the processes shows that changes in the protocol were not only made where activities were modified as a result of technology change (Act. 5, Act. 6). However, it may be noted that when there were changes in activities and/or resources and/or the intensity of resource use, there were always changes in the data and/or the information system that was used. In this case, two patterns of change were identified: (1) change in activities undertaken, the set of resources used, and the intensity of resource use. All this occurred in parallel with the use of new data and the application of a new information system (Act. 3 and Act. 4). (2) Only the set of resources and their intensity of use changed, in parallel with the application of a new information system, but no change was identified in activities carried out or data used (Act. 5, Act. 6).

3.2 Risk reduction for patients with metabolic syndrome (Case METSY)

In order to support the care of patients with metabolic syndrome, the development of telemedicine – as originally intended – focused on the use of a telemedicine system and smart devices that can track patients' lifestyles and health data (Table 2).

A nurse and a patient initiate the face-to-face healthcare delivery process (after prior appointment). First, patient admission (Act. 1) is carried out in the outpatient clinic (with the help of IT tools and other equipment). Then, with the assistance of the specialist doctor, the nurse, and the patient, the patient's medications and nutritional supplements (Act. 2), physical parameters (weight, height, blood pressure, etc.) (Act. 3) are recorded using the computer and medical equipment in the outpatient room. In addition to the above, the specialist conducts various tests (ECG, i.e. echocardiography) to define the patient’s health status (Act. 4). In the next step, the specialist derives further parameters that describe the patient's condition (creation of derived data, calculation of BMI, calculation of THR) (Acts. 5-7). After verifying eligibility to continue with the protocol (Act. 8), during a three-week hospital stay, the patient is informed on the therapy to be followed with the assistance of a specialist (Act. 9), a dietician (Act. 10), and a physiotherapist (Act. 11). During the hospital stay (Act. 12), the patient obtains access to the necessary materials, hospital facilities, and supervision by a nurse, a head nurse, a specialist, and a chief physician. Finally, the patient continues the therapy at home (Act. 13) for 90 days, in accordance with the recommendations, recording their diet, heart rate, weight, and blood pressure (using a monitoring watch, body weight scale, and sphygmomanometer) on a daily basis using a report sheet. The procedure ends with a final control examination after 90 days, when the initial examination is repeated (Act. 14-19).

Due to telemedicine development, the use of six new resources (telemedicine software, smart weight scale, smart monitoring watch, smart blood pressure monitor, data transmission unit, and smartphone) are identified. The introduction of the telemedicine technology led to minor and major changes in six activities. The initial examination resulted in the assessment of the patient's eligibility for the telemedicine protocol (Act. 8.1), followed by informing the patient of the telemedicine protocol and registering the patient’s information and consent (Act. 8.2). Although the set or use of resources did not change with the modification of this activity, new data (consent form, patient identified in the telemedicine system) were coded into a new information system in the telemedicine software.

Likewise, without any change in the resources used (due to the training on the use of different tools), the training of patients for therapy (Act. 9-12) was modified; moreover, its duration (thus the intensity of resource use) was reduced to five days.

Table 2 Changes in the protocol 'Risk reduction for patients with metabolic syndrome' due to technology change

				A4																A4			
				A4																A4			
				A4																A4			
				A4																A4			
			A4	A4															A4	A4			
			A4	A2												A4	A4		A4	A2			
			A4	A2												F5	F5		A4	A2			
			A4	F5												F5	F5		A4	F5			
		A4	A4	F4												F4	F4	A4	A4	F4			
		A4	F5	F4	A4	A4	A4	A4	A4							F4	F4	A4	F5	F4	A4	A4	A4
	A4	A4	F4	F4	A4	A4	A4	A4	A4							F4	F4	A4	F4	F4	A4	A4	A4
	A4	A4	F4	F4	A4	A4	A4	A4	A4			A4			F2	F4	F4	A4	F4	F4	A4	A4	A4
	A4	A4	F4	F4	A4	A4	A4	A4	A4	A4	A4	A4			F2	F4	F4	A4	F4	F4	A4	A4	A4
	A4	F5	F4	F3	A4	A4	A4	F5	F5	A4	A4	F5	A4		F2	H3	H2	F5	F4	F3	A4	A4	A4
	F5	F4	F4	F2	F5	F5	F5	F4	F4	F5	F5	F4	A4		F2	H3	H1	F4	F4	F2	F5	F5	F5
	F4	F4	F3	F2	F4	F4	F4	F4	F4	F4	F4	F4	A1	A4	A4	A4	A4	F4	F3	F2	F4	F4	F4
	F4	F4	F2	F2	F4	F4	F4	F4	F4	F4	F4	F4	H4	F6	A4	A4	A4	F4	F2	F2	F4	F4	F4
	F4	F4	F2	F2	F4	F4	F4	F4	F4	F4	F4	F4	H4	F5	F5	F5	F5	F4	F2	F2	F4	F4	F4
	F4	F4	F2	F2	F4	F4	F4	F4	F4	F4	F4	F4	H3	F5	F2	F2	F2	F4	F2	F2	F4	F4	F4
	F4	H2	H2	H2	F4	F4	F4	H2	H2	F4	F4	F3	H2	F4	F2	F2	F2	H2	H2	H2	F4	F4	F4
	H2	H1	H1	H1	H1	H1	H1	H1	H1	H1	H3	H3	H1	F4	F2	F2	F2	H1	H1	H1	H1	H1	H1
Activities	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8.1**	**8.2**	**9**	**10**	**11**	**12.1**	**12.2**	**13.1**	**13.2**	**13.3**	**14**	**15**	**16**	**17**	**18**	**19**
Time	5	50						5		150	60	600	1323	7200	16200	360	156	50					
Data										I / O	I					I / O	I / O						
Inf. system									O	I / O	I	I	I	I	I / O	I / O	I / O	I	I	I			

Source: the authors' compilation

The necessary information was (also) recorded in the telemedicine system, along with the (new) data on participation in training. However, the patient's home therapy has been radically transformed, with the patient using smart devices (smart monitoring watch, smart weight scale, smart blood pressure monitor, data transmission unit, smartphone) instead of traditional devices, and data are immediately recorded in the database of the telemedicine system (Act. 13.1). New activities naturally occur due to the changes above. The recorded data are analyzed by a dietician and a physiotherapist on a weekly basis (Act. 13.2), and, based on their assessment, a specialist assistant carries out consultations by telephone/online with patients, also on a weekly basis. Based on the results of the analysis and the weekly consultations, a specialist physician consults with the patient if necessary, potentially through telephone or online support (Act. 13.3). In this case, the new activities require additional office infrastructure (dietician's room, physiotherapist's room, medical room, and nurses' station), equipment (desk, chair, computer, monitor, and printer), consumables (paper, pen, suitable clothes) and an additional time commitment of specific resources. Regarding the check-up examinations, the activities, the resources used and the intensity of use of the latter do not change; only the input information system for the data originating from the tests that use medical devices (Acts 14 - 16) changed: details are recorded in the telemedicine system.

The modification of the protocol, as in the previous cases, involves a very wide range of changes, but it is worth emphasizing that the changes in the set and/or intensity of the resources used as a result of the technology change were not always accompanied by changes in the activities (e.g., Act. 8, Acts. 9-11). However, the changes were accompanied by the use of new data and/or new information systems during the related activities.

Five patterns of change were identified during the processing of the present case: (1) Changes during an activity that were not accompanied by changes in the set of resources or the intensity of their use. However, the changes in activity were accompanied by changes in the data set and the information system used (Act. 8). (2) The activity did not change, but the intensity of resource use involved in carrying out the activity changed, while the set of resources remained unchanged, and the set of data generated related to undertaking the activity and the information system that was used changed (Act. 9). (3) The activity did not change but the intensity of use of the resources did, while the set of resources remained unchanged. Only the information system used during the activity changed, while the data that was generated remained unchanged (Act. 10; Act. 11; Act. 12). (4) Both the activity and the set of used resources changed, as well as the intensity of their use. The change also generated data not previously used in this activity and used a new information system (Act. 13). (5) Neither the activities that were undertaken, the set of related resources, nor the intensity of use of resources changed. No changes were made to data generated during the activity, but a new information system was used in addition to that which existed (Actions 14-16).

3.3 Monitoring patients with heart failure (Case CARDIO)

As in the previous cases, the healthcare process related to monitoring patients with heart failure was carried out by integrating and utilizing smart devices based on the development of telemedicine technology. With the introduction of the new technology, a smart blood pressure monitor, a smart body weight scale, and telemedicine software for data transmission, data storage and data access were conceptualized as new devices.

In this case (Table 3), the care process starts with identification and registration (Act. 1) in a dedicated outpatient department. Then, after a short wait in the waiting room (Act. 2) at the ECG outpatient department, the ECG examination of the patient is undertaken (Act. 3) with the assistance of an ECG assistant and the appropriate IT/medical infrastructure and equipment. After the ECG examination and another short waiting period in the waiting room, 30% of patients undergo an echocardiogram scan (Act. 5). The echocardiogram is undertaken in a specific examination room by a cardiologist and a cardiology assistant with specific infrastructure, medical instruments, and IT equipment. After another waiting period, patients meet their cardiologist and their assistant. Again, interaction between the actors takes place in a dedicated examination room equipped with the necessary medical and IT infrastructure and specific equipment needed for the examination. During the examination, the patient's demographic data (Act. 7) and medical history (Act. 8) are recorded, followed by a physical examination (Act. 9), checking of vital signs (Act. 10), and an assessment of currently used medications (Act. 11). The examination also includes an evaluation of the ECG (Act. 12) and the echocardiogram results (Act. 13), and the patient's questioning (Act. 14) to help avoid adverse effects and/or events. The examination concludes with an agreement on the patient's home treatment prescription and the writing of a prescription (Act. 15). Depending on the examination results, one in five patients must have a blood test after another waiting room visit (Act. 17). Following the traditional healthcare delivery process, after three to six months of home treatment and follow-ups (Act. 19), the patient undergoes further control examinations (Act. 20-33), as described above. This results in discussion with the patient about the treatment outcome, other treatment options, and anything further that needs to be done (Act. 34).

The introduction of telemedicine technology has changed the face-to-face healthcare delivery process in two ways. First, during the identification of patients, it is necessary to check exclusion criteria and inform a patient and answer the patient's questions (Act. 7.1; 7.2). Another change results from the need to educate patients on the use of smart devices prior to self-monitoring at home (Act. 19.1). Other changes include the implementation of digital data collection and summarization (Act. 19.2) and the systematic analysis of digitally available data (Act. 19.3).

Changes in these activities were accompanied by changes in resources, data, and information systems used. For example, establishing exclusion criteria and the task of informing a patient no longer require the presence of consumables (paper towels). In the case of the seventh activity (Act. 7), the commitment of additional human resources, tools, and facilities is prolonged due to the observed changes. On the other hand, the start of the same activities requires recording the exclusion criteria data and the consent form for treatment as new data in line with the telemedicine protocol. Although these are still coded in the traditional way (on paper and in the existing healthcare information system), this allows the actors to use an additional data element (the identification of patients) in the telemedicine system. Patient education requires the presence of an additional human resource (cardiology specialist), the use of consumables (mask), and office infrastructure (examination room, rack, table, chair, computer, monitor, printer, telephone) necessary for their work, as well as smart devices (smart weight scale, smart blood pressure monitor, data transmission unit) necessary for training the patient and home treatment.

Calculating the measured data also requires the use of smart devices (smart weight scale, smart blood pressure monitor, data transmission unit), the patient's home, and the availability of the necessary consumables (paper, pen). The data analysis requires a cardiology assistant, office infrastructure (nursing station, desk, chair, computer, monitor, and printer), and office consumables (paper, pen, mask). As for changes in information, the application of the telemedicine system was identified as a new information system for the latter activities, in which the instructions for home therapy and the measured data describing the patient's condition are recorded.

Table 3 Changes in the protocol 'Monitoring patients with heart failure' due to technological change

			A4																								A4											
			A4		A4							A4									A4						A4		A4					A4					
			A4		A4							A4									F5						A4		A4					A4					
			A4		A4						A4	A4							A4		F5						A4		A4				A4	A4					
			A4		A4						A4	A4							A4		F4						A4		A4				A4	A4					
			A2		A2					A4	A4	F5	A4	A4	A4	A4	A4		A4		F4						A2		A2		A4	A4	A4	F5	A4	A4	A4	A4	A4
			A2		F5					A4	A4	F5	A4	A4	A4	A4	A4		A4		F4		A4				A2		F5		A4	A4	A4	F5	A4	A4	A4	A4	A4
			F5		F5					A4	F5	F4	A4	A4	A4	A4	A4		A4		F4		F4				F5		F5		A4	A4	F5	F4	A4	A4	A4	A4	A4
	A4		F5		F4					A4	F5	F4	A4	A4	A4	A4	A4		A2		F4		F4	A4		F5		F4			A4	A4	F5	F4	A4	A4	A4	A4	A4
	A4		F4		F4					F5	F4	F4	F5	F5	F5	F5	F5		F5		F4		F4	A4		F4		F4			F5	F5	F4	F4	F5	F5	F5	F5	F5
	A4		F4		F4					F5	F4	F4	F5	F5	F5	F5	F5		F5		F2		F4	A4		F4		F4			F5	F5	F4	F4	F5	F5	F5	F5	F5
	F5		F4		F4		A4	A4	A4	F4	F4	F4	F4	F4	F4	F4	F4		F4		F2	F2	F4	F5		F4		F4			F4	F4	F4	F4	F4	F4	F4	F4	F4
	F4		F4		F4		A4	A4	A4	F4	F4	F4	F4	F4	F4	F4	F4		F4		F2	F2	F4	F4		F4		F4			F4	F4	F4	F4	F4	F4	F4	F4	F4
	F4		F4		F4		A4	A4	A4	F4	F4	F2	F4	F4	F4	F4	F4		F4		H1	F2	H2	F4		F4		F4			F4	F4	F4	F2	F4	F4	F4	F4	F4
	F4		F4		F2		A4	A4	A4	F4	F4	F2	F4	F4	F4	F4	F4		F4		A4	A4	A4	F4		F4		F2			F4	F4	F4	F2	F4	F4	F4	F4	F4
	F4		F3		F2		F5	F5	F5	F4	F3	F2	F4	F4	F4	F4	F4		F4		A4	A4	A4	F4		F3		F2			F4	F4	F3	F2	F4	F4	F4	F4	F4
	F4	F5	F3	F5	F2	F5	F5	F5	F5	F4	F2	F2	F4	F4	F4	F4	F4	F5	F4	F5	F5	F5	F5	F4	F5	F3	F5	F2	F5	F4	F4	F2	F2	F4	F4	F4	F4	F4
	F4	F5	F2	F5	H2	F5	H2	H2	H2	H2	H2	H2	H2	H2	H2	H2	H2	F5	F3	F5	F2	F2	F2	F4	F5	F2	F5	H2	F5	H2	H2	H2	H2	H2	H2	H2	H2	H2
	H2	F4	H2	F4	H1	F4	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	F4	H2	F4	F2	F2	F2	H2	F4	H2	F4	H1	F4	H1	H1	H1	H1	H1	H1	H1	H1	H1
Activities	**1**	**2**	**3**	**4**	**5**	**6**	**7.1**	**7.2**	**7.3**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19.1**	**19.2**	**19.3**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
Time	5	30	10	30	13	30	5		30									30	1	30	30	1360	360	10	60	20	60	26	60	60								
Data							0	I / 0	I												I / 0	I / 0	I															
Inf. system							0	I / 0	I												I / 0	I / 0	I															

Source: the authors' compilation

The necessary information was (also) recorded.

In the last observed case, *telemedicine technology led to changes in two activities*. For both activities, the set of tasks to be undertaken, the resources used to carry out these tasks, and the intensity of their use changed. In parallel, the data generated by both activities and the number of information systems that are used also changed. However, in the present case, only this abovementioned pattern of change could be observed.

3.4 Application of peritoneal dialysis (Case DIAL)

Telemedicine support for the healthcare delivery process related to peritoneal dialysis included installing telemedicine software and smart devices capable of monitoring the characteristics of patients' dialysis at home.

In this case (Table 4), the patient route in the context of traditional medicine is carried out in such a way that apatient, already surgically prepared for peritoneal dialysis, is admitted by a nurse to a nursing room at the dialysis center, where a patient is identified with the help of IT tools (Act. 1). Patient is then seen by a specialist in an examination room, who uses the examination room equipment and IT equipment to record the patient's demographic data (Act. 2) and medical history (Act. 3), then examines the patient's physical characteristics (Act. 4), vital signs (Act. 5), dialysis-related data (Act. 6), and currently used medication (Act. 7). After the home dialysis parameters have been established, a patient is educated by a nephrology nurse on how to perform dialysis at home (Act. 8). Patient then continues the daily dialysis routine at home (Act. 9). Patients use their own facilities, kitchen scale, bodyweight scale, and blood pressure monitor. Finally, patients record their results on a report sheet provided by the clinic. The above-described visit to the dialysis center is repeated monthly, where – after patients are admitted – a specialist checks their dialysis data and, if necessary, adjusts the dialysis parameters (Act. 10-15).

The adaptation of telemedicine technology is conceptualized by the developers as the integration of four new resources (tablet, smart devices that can be connected to a tablet such as kitchen scale, body weight scale, blood pressure monitor, and telemedicine software) into the healthcare delivery process. This transforms three activities in the process: the recording of demographic data (Act. 2), patient education (Act. 8), and the dialysis routine at the patient's home (Act. 9). Prior to recording demographic data, it is necessary to verify the patient's eligibility for participation in the telemedicine protocol (Act. 2.1) and to inform patients and answer their questions about the care process (Act. 2.2). During patient education, training about the use of the telemedicine system and smart devices was a modification compared to the face-to-face patient route. The home dialysis routine was changed by the use of smart devices (Act. 9.1) and the regular clinical analysis of data (Act. 9.2) and the introduction of interventions in the case of unexpected adverse events (Act. 9.3) was a new activity.

The new activities that emerged while recording demographic data did not require mobilizing additional resources, but they did modify the deployment of existing resources.

Furthermore, this activity resulted in new data (patient consent form and identification in the telemedicine system) and the use of a new information system (telemedicine system). The change in patient education shows a different picture. Although the time required for the activity did not change, new resources (smart kitchen scale, body weight scale, blood pressure monitor) were used. New data were not interpreted in this case, but pre-existing input and output data were recorded in the telemedicine system. Finally, the modification of home dialysis involved a change in the resources (traditional devices were replaced by smart devices), and the analysis of the data required the presence of a nephrology nurse with an office and IT infrastructure. In the case of unexpected adverse events, the intervention required an additional resource; the presence of a specialist physician with an outpatient room and disposable materials (paper, pen, appropriate clothes, paper towels) necessary for an examination. These last two activities require more time than the traditional protocol. In the case of a change in home dialysis, the therapeutic suggestion of a change in therapy is a new data element; furthermore, data already present in the traditional protocol (data on blood pressure and body weight) are also included in the telemedicine system.

This case confirms that in the case of technology change not only do resources change in line with the modified activities, but in some cases the change in technology can result in a change in the set of resources or the intensity of their use without changing the activity itself (e.g., Act. 8). In the present case, however, it is identified that changes in the set of resources and/or the intensity of their use and/or the activities carried out are accompanied by changes in the data and/or information systems used during the related activity.

Four patterns of change could be observed in the peritoneal dialysis protocol supported by telemedicine technology: (1) Changes in the activities undertaken and the intensity of use of resources without changes in the set of resources. In this case, the information system and data used during the activity changed (Act. 2). (2) The activities, the set of resources, and the intensity of resource use changed with no change in the information systems and data used (Act. 9). (3) Only the set of resources changed, with no change in the activities used or resource-use intensity. The data employed here remained unchanged while a new information system was introduced (Act. 8). (4) Neither the activities, the set of resources used, nor the intensity of the resources that were used changed; only the information system used during the related activities was supplemented with a new information system – the telemedicine software (Act. 13).

Table 4 Changes in the protocol 'Application of peritoneal dialysis' due to technological change

													A4						
										F2			A4						
										F2			A4						
						A4				F2			A4		A4				
						A4				A4		F5	F5		A4				
						A4				A4		F4	F4	A4	A4				
						A4				A4		F4	F4	A4	A4				
		A4	A4	A4	A4	A4	A4	A4		A4		F4	F4	A4	A4	A4	A4	A4	A4
	A4	A4	A4	A4	A4	F5	A4	A4		A4	F2	F4	F4	A4	F5	A4	A4	A4	A4
	A4	A4	A4	A4	A4	F4	A4	A4		F5	F2	F4	F4	A4	F4	A4	A4	A4	A4
	A4	A4	A4	A4	A4	F4	A4	A4		F4	F2	H2	H1	A2	F4	A4	A4	A4	A4
	A4	A4	A4	A4	A4	F4	A4	A4		F4	A4	A4	A4	F5	F4	A4	A4	A4	A4
	F5	F5	F5	F5	F5	F4	F5	F5		F4	A4	A4	A4	F4	F4	F5	F5	F5	F5
	F4	F4	F4	F4	F4	F4	F4	F4	A4	F4	A4	A4	A4	F4	F4	F4	F4	F4	F4
	F4	F4	F4	F4	F4	F2	F4	F4	A4	F4	A3	A3	A3	F4	F2	F4	F4	F4	F4
	F4	F4	F4	F4	F4	F2	F4	F4	A4	F2	F5	F5	F5	F4	F2	F4	F4	F4	F4
	F4	F4	F4	F4	F4	F2	F4	F4	A4	F2	F2	F2	F2	F4	F2	F4	F4	F4	F4
	F4	F4	F4	F4	F4	F2	F4	F4	A4	F2	F2	F2	F2	F3	F2	F4	F4	F4	F4
	H2	H1	H1	H1	H1	H1	H1	H1	H1	H2	F2	F2	F2	H2	H1	H1	H1	H1	H1
Activities	**1**	**2.1**	**2.2**	**2.3**	**3**	**4**	**5**	**6**	**7**	**8**	**9.1**	**9.2**	**9.3**	**10**	**11**	**12**	**13**	**14**	**15**
Time	3	20		15						20	43800	120	15	33	165				
Data		O	I / O																
Inf. system		O	I / O							I / O	I / O	I	I / O				I		

Source: the authors' compilation

3.5 Increasing daily physical activity in patients with peripheral artery disease (Case PERIPHART)

For the treatment of patients with peripheral artery disease, the development of telemedicine technology also led to monitoring patients' activity at home using telemedicine software and smart devices. In this case, smart devices and telemedicine software were defined as new resources that support the home-based physical exercise of patients that are able to measure and transmit the results of physical exercise.

The process of patient care in the framework of traditional medicine starts in the outpatient department (Table 4), where a specialist assistant identifies and registers a patient through a referral (Act. 1). After checking the patient's eligibility for treatment (Act. 2), a specialist (with the help of a specialist assistant) informs a patient about the nature of the treatment and answers any questions that may arise (Act. 3). Then, with the assistance of the same actors and the help of the outpatient department infrastructure, IT, and medical equipment, the patient's initial assessment is carried out, involving recording demographic data (Act. 4), medical history (Act. 5), vital signs (Act. 6), and currently used medication (Act. 7). The examination includes a physical examination of a patient: first, a functional examination (Act. 8) is undertaken, then one of objective walking distance (Act. 9), and the Ankle Brachial Index (Act. 10) is calculated. The initial examination concludes with a summary of the therapy and consultation with a patient (Actions 11-12). Patient then regularly carries out the therapy-recommended physical exercises at home, using equipment, and records the results on a report sheet (Act. 13). After three and six months, a patient is examined again in the same way as at the initial examination, and a physiotherapist participates in the examination alongside the original practitioners (Act. 15-20). The follow-up examinations lead to agreement with a patient regarding the continuation of the therapy and what further actions should be taken (Act 21).

Telemedicine technology development resulted in use of a smart scale, a smart blood pressure monitor, a smartwatch, a stair climber, a transceiver, and telemedicine software to support the patient's home mobility, causing changes in four activities in the protocol. First, the activity related to informing a patient (Act. 3) was modified (the focus changed to explaining the telemedicine protocol). Further, the therapy suggestion was (also) recorded in the telemedicine system (Act. 12). Third, the parameters of the patients' home exercise (Act. 13) were routinely recorded and transmitted by the smart devices (Act. 13.1) and then analyzed and reported back to patients by a cardiology nurse (Act. 13.2). Finally, modification is recognized in the need to identify patients in the telemedicine system for further checks; moreover, their activity-related data becomes available (Act. 15).

Due to the changes in technology, changes in resources and information occurred in parallel with changes in activities. In fact, the change in the information provided to patients involved the introduction of new input data (meeting selection criteria) and a new information system (patient identification in the telemedicine system), which was accompanied by the completion of a consent form by a patient. In fact, recording the therapeutic suggestion in the telemedicine system also involved the introduction (and use) of the telemedicine system. Furthermore, changing the patients' physical exercise routine at home required smart devices (smart weight scale, smart blood pressure monitor, data transmission unit, stair machine, smartwatch). Furthermore, the data analysis required the additional workload of a cardiology nurse in the analysis, as well as the use of office and IT infrastructure (nursing station, desk, chair, computer, monitor, printer, telephone) and consumables (paper, pen, appropriate clothes). Finally, a new data element (patient identification) and the telemedicine system were resources additionally required for the checkups.

Table 5 Changes in the protocol 'Risk reduction for patients with metabolic syndrome' due to technology change

																	A4				A4	
						A4				A4							A4				A4	
						A4				A4							A4		A4		A4	
						A4		A4		A4						A4	A4	A4	A4	A4	A4	A4
				A4	A4	A4	A4	A4	A4	A4		A4		A4		A4	A4	A4	A4	A4	A4	A4
				A4	A4	A4	A4	A4	A4	A4	A4	A4		A4		A4	F5	A4	A4	A4	A2	A4
				A4	A4	F5	A4	A4	A4	A2	A4	A4		A4		A4	F4	A4	A4	A4	F5	A4
	A4	A4		A4	A4	F4	A4	A4	A4	F5	A4	A4		F5		A4	F4	A4	F5	A4	F4	A4
	A4	A4	A4	A4	A4	F4	A4	F5	A4	F4	A4	F5		F4	A4	F5	F4	F5	F4	F5	F4	F5
	A4	A4	A4	F5	F5	F4	F5	F4	F5	F4	F5	F4		F4	A4	F4	F4	F4	F4	F4	F4	F4
	A4	A4	A4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F2	F4	A4	F4	F4	F4	F4	F4	F4	F4
	F5	F5	A4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F2	F4	A4	F4	F4	F4	F4	F4	F4	F4
	F4	F4	F5	F4	F4	F4	F4	F4	F4	F4	F4	F4	F2	F4	F5	F4	F3	F4	F4	F4	F4	F4
	F4	F4	F4	F4	F4	F3	F4	F4	F4	F4	F4	F4	F2	F4	F4	F4	F2	F4	F4	F4	F3	F4
	F4	F4	F4	F4	F4	F2	F4	F4	F4	F3	F4	F4	F2	H3	F4	F4	F2	F4	F3	F4	F2	F4
	F4	F4	F4	F4	F4	F2	F4	F3	F4	F2	F4	F2	A3	A3	F4	F3	F2	F3	F2	F3	F2	F3
	F4	F4	F4	F3	F3	F2	F3	F2	F3	F2	H3	H3	A3	A3	F4	H3	H3	H3	H3	H3	H3	H3
	H2	H2	F4	H2	H2	H2	H2	H2	H2	H2	H2	H2	A3	A3	F4	H2	H2	H2	H2	H2	H2	H2
	H1	H1	H2	H1	H1	H1	H1	H1	H1	H1	H1	H1	F5	F5	H2	H1	H1	H1	H1	H1	H1	H1
Activities	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**13.2**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Time	5	5		15							5	5	3600	360	5	80						
Data			I / O									I / O	I / O	I		I						
Inf. system			I / O									I / O	I / O	I		I						

Source: the authors' compilation

The analyses show that, two activities changed due to the use of telemedicine technology (Act. 3 and Act. 13), while the change in activities was accompanied by a change in resources in only one case. Three patterns of change that occurred during the case could be identified. (1) Change in an activity that did not cause a change in either the set of resources or the intensity of their use, but resulted in new data coded into a new information system (Act. 3). (2) The set of activities and resources and the intensity of their use changed. The set of data that was generated and the scope of the information systems used also changed (Act. 13). (3) Neither the activities, the set of resources, nor their intensity of use changed. No change could be detected in the set of data reported, but there was a change in the information system used (Act. 12; Act. 15).

Conclusion

Our research confirms the findings of Basto et al. (2019) and Dóra and Szalkai (2020) that changes related to activities, resources, and information pathways are intertwined in healthcare processes. Our analysis further demonstrates, in line with the findings of Middleton et al. (2020) and Zanotto et al. (2020), that the digital platform that is used and the way information is managed define the characteristics of both patient care activities and resources used.

On the other hand, the results confirm the correlations identified in previous studies of resource interaction. According to the latter, technology is considered more as an interface than a resource, where changes in interfaces (namely, interconnections between resources) inevitably induce changes in activities, resource constellations, or the intensity of resource use (Baraldi et al., 2012; Prenkert et al., 2019). However, our findings go beyond these observations and show that technological change can be captured through changes in information systems and the data that is used when digital technologies (telemedicine, telehealth applications) are introduced or modified. Changes in information systems and such data indicate changes in activities, resource constellations, and resource-use intensity.

In some cases the technological change concerned the configuration and exploitation of digital technology in specific healthcare protocols, where the introduction of the new technology led to numerous spill-over effects. These findings are consistent with both the general experience of interpreting the effects of technological change (Håkansson et al., 2009; Hu et al., 2002) and observations about telemedicine and telehealth developments (Parikh et al., 2020; Portney et al., 2020; Bauer et al., 2020; Middleton et al., 2020; Rodrigues et al., 2021).

In the cases that were studied, the observed changes in resources as a result of technological change seemed to occur without any apparent pattern. In some cases, the new technology generated new/changed activities, new/changed resource sets, and – in parallel – a change in the intensity of resource use. In other cases, only the resources involved in the activities and the intensity of resource use changed, while the activities that were carried out remained unchanged. Last, we also identified a few cases in which only the activities undertaken, or the resource set, or the intensity of resource use changed. However, for all the cases examined, the changes not only affected the activities for which the new tools/resources were introduced, but there were also spill-over effects. These took many forms, which shows the nature and characteristics of the changes (Δ) that occurred based on the patterns of change summarized in the analysis of each case study.

We can see in all cases, the changes observed as a result of technological change occurred in parallel with changes in the data that was used and the information systems employed. If there is a change in the data that is used and the information system at the same time, in all cases there are changes in the observed characteristics; i.e. in the activities to be carried out and/or in the resources used and/or in the intensity of resource use. These changes may be classified into four groups: all three observed characteristics changed (activity, resource composition, resource intensity) (Group A); the activities and the intensity of resource use changed (Group B); only the activities changed (Group C); or only the intensity of resource use changed (Group D).

It was also discovered that if the change in technology only leads to a change in the information system that is used (with no change in the data used), in some cases there is a change in the activities, the resources used, and/or the intensity of resource use, while in other cases there is no observed change. However, as the information system changed, there were changes in the resource set and the intensity of their use in the ENT protocol (ENT 2). Moreover, changes only in the resource set in the DIAL protocol (DIAL 3) and changes only in the intensity of resource use in the METSY protocol (METSY 3) were detected when a change in the information system applied was identified.

Finally, changes exclusively in the data being used (without modification of the information system) could not be identified. Furthermore, no change could be identified when an adjustment was made to activities and/or in the resource set and/or the intensity of resource use without a change in the data or information system.

In our research we sought to answer the research question of how to identify the extent of change in resources caused by a technological change. Our investigation led us to the following conclusion: we found that a technological change transforms a business process, and hence value creation itself, to the extent that its steps (activities) use new information encoded in a changed information system.

Our research focused on examining the emergence of technology induced change and identifying patterns of change in activities and resources, and the intensity of resource use in health service organizations. The research produced a number of striking results. On the one hand, our results confirm that in the case of telemedicine and telehealth applications, the impact of technological change is not limited to the process steps whereby new tools and equipment are introduced. Instead, spillover effects with apparently unpredictable patterns are generated, which may be reflected in changes in the activities undertaken during different process steps, resource sets to be used, or the intensity of their use.

Our results also showed that, due to technological change, changes in information systems were likely to result, while simultaneous changes in data used and information systems together clearly predicted changes in activities, resources, and the intensity of resource use in the observed cases. In the case of changes due to modifications of technology, we found no examples of changes in activities, resources, or resource use intensity without changes in data and/or information systems.

Our research suggests that applying the TDABC methodology can help trace such changes. Furthermore, it suggests that TDABC methodology should be complemented by systematic monitoring of the information system and data content, allowing greater localization and analysis of the scope of changes in the case of technological change. Our investigations suggest that monitoring the data and information systems used to track and implement activities can be used as predictors of change.

The most significant limitation to generalizing our findings is the research context itself. Our study was conducted in the context of healthcare protocols, where we were able to take into account a number of specificities (such as the healthcare-process-specific context of the TDABC methodology), and the specific circumstances and sector-specific characteristics of the healthcare sector limit the generalizability of our results. A further limitation is the number of cases that were observed and the research method itself. We investigated the consequences of technological change in the context of five healthcare protocols within the framework of an organization using case-study methodology. Although the number of observations and the chosen research method allowed us to make in-depth observations, they do not permit us to make organization- and sector-independent observations. This suggests the need for further research, which can also lead to the opportunity to investigate the effectiveness of traditional and telemedicine-supported healthcare delivery processes. Furthermore, it also seems justified to test TDABC methodology and examine its potential added value based on the approach described in this study.

Declarations

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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References

Akdaş, O. & Cismaru, M. (2022). Promoting mental health during the COVID-19 pandemic: the transtheoretical model of change and social marketing approach. *International Review on Public and Nonprofit Marketing*, 19, 447-474. https://doi.org/10.1007/s12208-021-00307-1

Allin, O., Urman, R. D., Edwards, A. F., Blitz, J. D., Pfeifer, K. J., Feeley, T. W. et al. (2020). Using Time-Driven Activity-Based Costing to Demonstrate Value in Perioperative Care: Recommendations and Review from the Society for Perioperative Assessment and Quality Improvement (SPAQI). *Journal of Medical Systems*, (44)25, 1-8. https://doi.org/10.1007/s10916-019-1503-2

Baraldi, E., Gressetvold, E., & Harrison, D. (2012). Resource interaction in inter-organizational networks: Foundations, comparison, and a research agenda. *Journal of Business Research*, 65(2), 266–276. https://doi.org/10.1016/j.jbusres.2011.05.030

Basto, J., Chahala, R., & Riedel, B. (2019). Time-driven activity-based costing to model the utility of parallel induction redesign in high-turnover operating lists. *Healthcare*, 7. https://doi.org/10.1016/j.hjdsi.2019.01.003

Bauer, B. S., Nguyen-Phan, A. L., Ong, M. K., Ziaeian, B., & Nguyen, K. L. (2020). Cardiology electronic consultations: Efficient and safe, but consultant satisfaction is equivocal. *Journal of telemedicine and telecare*, 26(6), 341-348. https://doi.org/10.1177/1357633X19828130

Bizzi, L., & Langley, A. (2012). Studying processes in and around networks. *Industrial Marketing Management*, 41(2), 224–234. https://doi.org/10.1016/j.indmarman.2012.01.007

Bocconcelli, R., Carlborg, P., Harrison, D., Hasche, N., Hedvall, K., & Huang, L. (2020). Resource interaction and resource integration: Similarities, differences, reflections. *Industrial Marketing Management*, 91, 385–396. https://doi.org/10.1016/j.indmarman.2020.09.016

Bodar, Y. J. L., Srinivasan A. K., Shah A. S., Kawal T., & Shukla A. R. (2020). Time-Driven activity-based costing identifies opportunities for process efficiency and cost optimization for robot-assisted laparoscopic pyeloplasty. *Journal of Pediatric Urology*, 16. 460e1-460e10. https://doi.org/10.1016/j.jpurol.2020.05.146

Burnes, B. (2004). *Managing Change: A Strategic Approach to Organisational Dynamics*, 4th Ed. Harlow, Prentice Hall.

By, R. T. (2005). Organisational change management: A critical review*. Journal of Change Management,* 5(4) 369-380. https://doi.org/10.1080/14697010500359250

Byrnes, P., & Valdmanis, V. (1993). Analyzing technical and allocative efficiency of hospitals. In Charnes, A., Cooper, W. W., Lewin, A. Y., Seiford, L. M. (Eds.), *Data envelopment analysis: Theory, methodology and applications*, 129-144. Kluwer. https://doi.org/10.1007/978-94-011-0637-5_7

Cantù, C., Corsaro, D., & Snehota, I. (2012). Roles of actors in combining resources into complex solutions. *Journal of Business Research*, 65(2), 139–150. https://doi.org/10.1016/j.jbusres.2011.05.013

Choudhery S., Hanson A. L., Stellmaker, J. A., Ness J., Chida L., & Conners A. L. (2021). Basics of time-driven activity-based costing (TDABC) and applications in breast imaging. *The British Journal of Radiology*, 94(1119). https://doi.org/10.1259/bjr.20201138

Cidav, Z., Marcus, S., Mandell, D., Hornbrook, M. C., Mo, J. J., Sun, V., Ercolano, E., Wendel, C. S., Weinstein, R. S., Holcomb, M. J., Grant, M., Rock, M. & Krouse, R. S. (2021). Programmatic Costs of the Telehealth Ostomy Self-Management Training: An Application of Time-Driven Activity-Based Costing. *Value in Health*, *24*(9), 1245-1253. https://doi.org/10.1016/j.jval.2021.03.018

Crespin-Mazet, F., Grenier, C., E, C., Goglio-Primard, K., & Lombardo, E. (2014). Developing a usage network: Combining business and non-business resources to implement innovation. *IMP Journal*, 8, 133-149.

Dóra, T. B., & Szalkai, Z. (2020). The impacts of a new type of actor as an intermediary in public–private collaboration in health-care prevention. *Journal of Business and Industrial Marketing*, 36(3), 420-435. https://doi:10.1108/JBIM-12-2019-0509

Dóra, T. B., Mátó, Á. R., Szalkai, Z. & Vilmányi, M. (2022). The role of information in relation to interaction affected by technology change – the case of a telemedicine pilot project, *Journal of Business & Industrial Marketing*, 38(8), 1639-1655. https://doi.org/10.1108/JBIM-02-2022-0065

Edvardsson, B., Tronvoll, B., & Gruber, T. (2011). Expanding understanding of service exchange and value co-creation: A social construction approach. *Journal of the Academy of Marketing Science*, 39(2), 327–339. https://doi.org/10.1007/s11747-010-0200-y

Etges A. P. B.S., Polanczyk C. A., & Urman R. D. (2020a). A standardized framework to evaluate the quality of studies using TDABC in healthcare: the TDABC in Healthcare Consortium Consensus Statement. *BMC Health Services Research*, *20*(1107), 1-15. https://doi.org/10.1186/s12913-020-05869-0

Etges A. P.B.S., Ruschel K. B., Polanczyk C. A., & Urman R. D. (2020b). Advances in Value-Based Healthcare by the Application of Time-Driven Activity-Based Costing for Inpatient Management: A Systematic Review. *Value in Health, 23*(6), 812–823. https://doi.org/10.1016/j.jval.2020.02.004

Etges, A. P. B.S., Cruz, L. N., Notti R. K., Neyeloff, J. L., Schlatter R. P., Astigarraga C. C. et al. (2019). An 8-step framework for implementing time-driven activity-based costing in healthcare studies. *The European Journal of Health Economics,* 20, 1133–1145. https://doi.org/10.1007/s10198-019-01085-8

Etges, A.P.B.S., Zanotto, B. S., Ruschel, K. B., da Silva, R. S., Oliveira, M., de Campos Moreira, T. et al. (2022). Telemedicine Versus Face-to-Face Care in Ophthalmology: Costs and Utility Measures in a Real-World Setting. *Value in Health Regional Issues*, 28, 46-53. https://doi.org/10.1016/j.vhri.2021.06.011

Fang C., Pagani N., Gordon M., Talmo C. T., Mattingly D. A., & Smith E. L. (2021). Episode-of-Care Costs for Revision Total Joint Arthroplasties by Decadal Age Groups. *Geriatrics*, 6(2), 49. https://doi.org/10.3390/geriatrics6020049

Farmer, A. J., Stevens, R., Hirst, J., Lung, T., Oke, J., Clarke. P., et al. (2014). Optimal strategies for identifying kidney disease in diabetes: properties of screening tests, progression of renal dysfunction and impact of treatment – systematic review and modelling of progression and cost-effectiveness. *Health Technology Assessment*, 18(14), 1-128. https://doi.org/10.3310/hta18140

Frow, P., McColl-Kennedy, J. R., & Payne, A. (2016). Co-creation practices: Their role in shaping a health care ecosystem. *Industrial Marketing Management*, 56, 24–39. https://doi.org/10.1016/j.indmarman.2016.03.007

Garoon, R. B., Lin, W. V., Young, A. K., Yeh, A. G., Chu, Y. I., & Weng, C. Y. (2018). Cost savings analysis for a diabetic retinopathy teleretinal screening program using an activity-based costing approach. *Ophthalmology Retina*, 2(9), 906-913. https://doi.org/10.1016/j.oret.2018.01.020

Gressetvold, E. (2001). *Technical Development within the Industrial Network Approach as Interaction Between Four Resource Entities.* In 17th IMP Conference in Oslo, Norway.

Håkansson, H. & Waluszewski, A. (2002). *Managing Technological Development. IKEA, the Environment and Technology.* Routledge, London. http://dx.doi.org/10.4324/9780203217535

Håkansson, H. & Waluszewski, A. (2007). *Knowledge and Innovation in Business and Industry: The Importance of Using Others*. Routledge, London. https://doi.org/10.4324/9780203947029

Håkansson, H. (2009). Comments on "Actors, resources, activities and commitments". *Industrial Marketing Management. 38*(5), 562-562. https://doi.org/10.1016/j.indmarman.2009.02.006

Håkansson, H., & Snehota, I. (1995). *Developing Relationships in Business Networks*. Routledge.

Håkansson, H., Ford, D., Gadde, L. E., Snehota, I., & Waluszewski, A. (2009). *Business in Networks*, John Wiley and Sons.

Håkansson, H., Ford, D., Gadde, L.-E., Snehota, I. & Waluszewski, A. (2009). *Business in Networks*. Wiley.

Hu, P. J. H., Chau, P. Y. K., & Sheng, O. R. L. (2002). Adoption of Telemedicine Technology by Health Care Organizations: An Exploratory Study. *Journal of Organizational Computing and Electronic Commerce*, 12(3), 197–221. https://doi.org/10.1207/S15327744JOCE1203_01

Kaplan, R. S. & Porter, M. E. (2011). The Big Idea: How to Solve the Cost Crisis in Health Care. *Harvard Business Review*, September, 89(9) 46-52.

Kaplan, R. S., & Anderson, S. R. (2004). Time-Driven Activity-Based Costing. *Harvard Business Review*, November 82(50), 131-8.

Kaplan, R. S., Witkowski, M., Megan Abbott, M., Guzman, A. B., Higgins, L. D., Meara, J. G. et al. (2014). Using Time-Driven Activity-Based Costing to Identify Value Improvement Opportunities in Healthcare. *Journal of Healthcare Management*, 59(6), 399-412. https://doi.org/10.1097/00115514-201411000-00005

Keel, G., Muhammad, R., Savage, C., Spaak, J., Gonzalez, I., Lindgren, P. et al. (2020). Time-driven activity-based costing for patients with multiple chronic conditions: a mixed-method study to cost care in a multidisciplinary and integrated care delivery centre at a university-affiliated tertiary teaching hospital in Stockholm, Sweden. *BMJ Open*, 10(6), e032573. http://dx.doi.org/10.1136/bmjopen-2019-032573

Keel, G., Savage, C., Rafiq, M., & Mazzocato, P. (2017). Time-driven activity-based costing in health care: A systematic review of the literature. *Health Policy*, 121(7), 755-763. https://doi.org/10.1016/j.healthpol.2017.04.013

Kukreja, J. B., Seif, M. A., Mery, M. W., Incalcaterra, J. R., Kamat, A. M., Dinney, C. P., et al. (2021). Utilizing time-driven activity-based costing to determine open radical cystectomy and ileal conduit surgical episode cost drivers. *Urologic Oncology: Seminars and Original Investigations*, 39, 237.e1−237.e5 https://doi.org/10.1016/j.urolonc.2020.11.030

Langley, A. (1999). Strategies for Theorizing from Process Data. *The Academy of Management Review*, 24(4), 691-710. https://doi.org/10.2307/259349

LeRouge, C., Tulu, B., & Forducey, P. (2010). The Business of Telemedicine: Strategy Primer. *Telemedicine and eHealth*, 16(8), 898-909. https://doi.org/10.1089/tmj.2009.0178

Ley, E. (1991). Eficiencia productiva: Un estudio aplicado al sector hospitalario. *Investicaionnes Económicas*, 15(1), 71-88.

Lopez-Valcarcel, B.G. & Perez, P.B. (1996). Changes in the efficiency of Spanish public hospitals after the introduction of program-contracts, *Investigaciones Económicas*, 20 (3), 377-402.

Maniadakis, N., & Thanassoulis, E. (2000). Assessing productivity changes in UK hospitals reflecting technology and input prices. *Applied Economics*, *32*(12), 1575-1589. https://doi.org/10.1080/000368400418970

Middleton, A., Simpson, K. N., Bettger, J. P., & Bowden, M. G. (2020). COVID-19 pandemic and beyond: Considerations and costs of telehealth exercise programs for older adults with functional impairments living at home—Lessons learned from a pilot case study. *Physical therapy*, 100(8), 1278-1288. https://doi.org/10.1093/ptj/pzaa089

Ostrenga, M. R., Ozan, T. R., McIlhattan, R. D., & Harwood M. D. (1992). *The Ernst & Young Guide to Total Cost Management.* John Wiley and Sons.

Parikh, N. R., Chang, E. M., Kishan, A. U., Kaprealian, T. B., Steinberg, M. L., & Raldow, A. C. (2020). Time-Driven Activity-Based Costing Analysis of Telemedicine Services in Radiation Oncology. *International Journal of Radiation Oncology Biology Physics*, 108(2), 430-434. https://doi.org/10.1016/j.ijrobp.2020.06.053

Pathak, S., Snyder, D., Kroshus, T., Keswani, A, Jayakumar, P., Esposito, K. et al., (2019). What Are the Uses and Limitations of Time-driven Activity-based Costing in Total Joint Replacement? *Clinical orthopaedics and related research*, 477(9), 2071-2081. https://doi.org/10.1097/CORR.0000000000000765

Paul, D. L., Pearlson, K. E., & McDaniel, R. R. (1999). .Assessing technological barriers to telemedicine: technology-management implications. *IEEE Transactions on Engineering Management*, 46(3), 279-288. https://doi: 10.1109/17.775280.

Pauli, G., Martin, S. & Greiling, D. (2023). The current state of research of word-of-mouth in the health care sector. *International Review on Public and Nonprofit Marketing,* 20, 125–148. https://doi.org/10.1007/s12208-022-00334-6.

Penrose, E.T. (1959). *The Theory of the Growth of the Firm*. John Wiley & Sons.

Pettigrew, A. M. (1997). What is a processual analysis? *Scandinavian Journal of Management*, 13(4), 337–348. https://doi.org/10.1016/S0956-5221(97)00020-1

Pettigrew, A.M. (1985). Contextualist Research and the Study of Organizational Change Processes. In: Lawler, E. (Ed.): *Doing Research That is Useful for Theory and Practice.* Jossey-Bass, San Francisco.

Popat, K., & Guzman, A. B. (2018). Using Time-Driven Activity-Based Costing to Model the Costs of Various Process-Improvement Strategies in Acute Pain Management. *Journal of Healthcare Management*, 63(4), e76-e85. https://doi.org/10.1097/jhm-d-16-00040

Porter, M. E. (2010). What Is Value in Health Care? *New England Journal of Medicine*, 363(26), 2477–2481. https://doi.org/10.1056/NEJMp1011024

Portney, D. S., Ved, R., Nikolian, V., Wei, A., Buchmueller, T., Killaly, B. et al. (2020). Understanding the cost savings of video visits in outpatient surgical clinics. *Mhealth*, 6(32). https://doi.org/10.21037/mhealth-20-33

Prenkert, F., Hasche, N., & Linton, G. (2019). Towards a systematic analytical framework of resource interfaces. *Journal of Business Research*, 100, 139–149. https://doi.org/10.1016/j.jbusres.2019.03.027

Puskin, D., Johnston, B., & Speedie, S. (2006 September 12.). *Telemedicine, Telehealth, and Health Information Technology*. The American Telemedicine Association issue paper. https://www.who.int/goe/policies/countries/usa_support_tele.pdf?ua=1

Reardon, T. (2005). Research Findings and Strategies for Assessing Telemedicine Costs. *Telemedicine and eHealth*, 11(3), 348-371. https://doi.org/10.1089/tmj.2005.11.348

Rodrigues, D. L. G., Belber, G. S., Padilha, F. V. D. Q., Spinel, L. F., Moreira, F. R., & Maeyama, M. A. (2021). Impact of Teleconsultation on Patients With Type 2 Diabetes in the Brazilian Public Health System: Protocol for a Randomized Controlled Trial (TELEconsulta Diabetes Trial). *JMIR Research Protocols*, 10(1). https://doi.org/10.2196/23679

Rodrigues, D. L. G., Belber, G. S., Padilha, F. V. D. Q., Spinel, L. F., Moreira, F. R., & Maeyama, M. A. (2021). Impact of Teleconsultation on Patients With Type 2 Diabetes in the Brazilian Public Health System: Protocol for a Randomized Controlled Trial (TELEconsulta Diabetes Trial). *JMIR Research Protocols*, *10*(1). https://doi.org/10.2196/23679

Sadri, H., Sinigallia, S., Shah, M., Vanderheyden, J., & Souche, B. (2021). Time-Driven Activity-Based Costing for Cataract Surgery in Canada: The Case of the Kensington Eye Institute. *Healthcare Policy*, 16(4), 97-108. https://doi.org/10.12927/hcpol.2021.26496

Schwamm, L. H. (2014). Telehealth: Seven Strategies to Successfully Implement Disruptive Technology and Transform Health Care. *Health Affairs*, 33(2), 200-206. https://doi.org/10.1377/hlthaff.2013.1021

Sikandar, H., Abbas, A. F., Khan, N., & Qureshi, M.I. (2022). Digital Technologies in Healthcare: A Systematic Review and Bibliometric Analysis. *International Journal of Online and Biomedical Engineering (iJOE)*, 18(08), 34–48. https://doi.org/10.3991/ijoe.v18i08.31961

Sisk, J. E., & Sanders, J. H. (1998). A Proposed Framework for Economic Evaluation of Telemedicine. *Telemedicine Journal*, 4(1), 31-38. https://doi.org/10.1089/tmj.1.1998.4.31

✉ Correspondence

Margit Tarjányi

University of Szeged, Faculty of Economics and Business Administration, Business Studies,
H-6722, Kálvária sgt. 1., Szeged, Hungary

E-mail: tarjanyi.margit@eco.u-szeged.hu

Thaker, N. G., Orio, P. F., & Potters, L. (2017). Defining the value of magnetic resonance imaging in prostate brachytherapy using time-driven activity-based costing. *Brachytherapy*, 16(4), 665-671. https://doi.org/10.1016/j.brachy.2016.11.013

Van de Ven, A. H. (1992). Suggestions for studying strategy process: a research note. *Strategic Management Journal*, 13(1), 169-188. https://doi.org/10.1002/smj.4250131013

Van de Ven, A. H., & Huber, G. P. (1990). Longitudinal Field Research Methods for Studying Processes of Organizational Change. *Organization Science*, 1(3), 213–219. https://doi.org/10.1287/orsc.1.3.213

Weick, K. E. & Quinn, R. E. (1999). Organizational change and development. *Annual Review of Psychology,* 50, 361-386. https://doi.org/10.1146/annurev.psych.50.1.361

Wells, R. A., Gallarza, M. G., Andreu, L., & Calero, R. (2015). Application of Service Dominant Logic to the medical device industry. *International Review on Public and Nonprofit Marketing, 12(3), 207–235.*

Whelan-Berry, K. S. & Somerville, K. A. (2010). Linking Change Drivers and the Organizational Change Process: A Review and Synthesis. *Journal of Change Management*, 10(2) 175-193. https://doi.org/10.1080/14697011003795651

Zanotto, B. S., Etges, A. P. B. D. S., Siqueira, A. C., Silva, R. S. D., Bastos, C., Araujo, A. L. D. et al., (2020). Economic evaluation of a telemedicine service to expand primary health care in Rio Grande do Sul: TeleOftalmo's microcosting analysis. *Ciencia & saude coletiva*, 25(4), 1349-1360. https://doi.org/10.1590/1413-81232020254.28992019