An Engineering Method to Evaluate Care Processes and Introduce Televisits

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Abstract. During past years, the pandemic has revealed the importance of having a solid care system prepared to face emergencies. In this context, digital solutions demonstrated a high potential in dealing with critical conditions and ensuring the delivery of care. However, telemedicine has not yet succeeded in becoming a stable part of ordinary care. The integration of innovative telemedicine technologies with a set of well-organized activities plays a crucial role in the release of high-quality services. Processes modeling before the introduction of telemedicine services is a leverage to prepare the base for an effective and efficient shift to digital care. Hence, the present research customizes a modeling technique in four steps for a preliminary analysis of processes where to introduce televisits. A special attention is given to the collection of consistent knowledge about care processes, often lack and incomplete in public hospitals scenarios. The approach has been applied to the AS-IS process of the heart failure clinic of a large Italian hospital before the introduction of televisits. Integrated Definition for Function Modeling (IDEF) diagrams have allowed the hierarchical decomposition of complex phases in simpler tasks, the acquisition of consciousness and the updating of information. Diagrams have been created and used as a source of a common language to discuss about weaknesses of the current process and its possible improvements. Obstacles to the upcoming televisits services have been objectively highlighted, such as the need to reduce employed applications, the removal of printed material and the streamlining of unnecessary operations.

Keywords: IDEF0 · Process modeling · Healthcare processes · Televisits

1 Introduction

The severe impact of coronavirus disease 19 (Covid-19) on the health systems of different countries has revealed the necessity to better organize processes of care, in order to guarantee the right service levels. Indeed, the delay of non-urgent procedures due to hospitals overcrowding has generated a negative effect, especially on frailty and chronic patients, who require ongoing assistance [1–3]. In such a context, telemedicine solutions

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have proved to be effective instruments to face difficult scenarios and prevent the possible future lack of care continuity [4].

Telemedicine ensures the communication among health professionals, patients and caregivers by means of video communication and the fast exchange of documents and medical records [5]. Its advantages can be summarized as: accessible care, increased convenience, enhanced comfort, greater confidentiality to patients and families, and reduced risk of Covid-19 contagion [6]. The introduction of telemedicine services and the consequent modernization of instrumentation is a choice adopted to create a more solid and stable health care system [7]. However, several barriers are responsible for the limited diffusion of telemedicine activities, which are often not included in ordinary care yet. Among the found limitations, the principal concern technological aspects, the organization of activities and the quality of interaction between physicians and patients [8, 9].

Working on hospital processes can be a way to better plan and control how care services are delivered. Process management techniques are already used in the healthcare field for designing and monitoring activities carried out by healthcare professionals [10]. In particular, the representation of processes is a tool useful for helping medical personnel in understanding weaknesses and discussing future improvements. Accordingly, the investigation and the mapping of care processes can be the preliminary step for the effective future introduction of telemedicine services inside hospital clinics. It can allow the detection of the workflow, the consumption of resources and the sharing of places during indoor activities among personnel. However, the availability of complete and structured information as a source for a realistic healthcare process representation is still limited.

Based on the exposed context, the present research investigates a methodology for the acquisition of formal knowledge and the representation of hospital processes, before the introduction of televisits for a guided reorganization of the activities. Following sections investigate the background, including the research of business process modeling in the health and e-health field. After the definition of the objective, further sections define the main steps of the proposed methodology and its application to a case study. Discussions and conclusions are finally drawn.

2 Scientific Background

The combination of new researches and innovative technical equipment allowed the definition of high-quality care solutions, paying attention to satisfy patients' needs. On the other hand, the limited availability of resources and the need for new administrative and medical requirements have led to the necessity of redesigning clinical processes and reorganizing their flow of activities.

The management of processes is a strategic leverage to improve operational performance, enhance service quality and ensure regulations and compliance [11]. Previous researches have already investigated the application of business process techniques in the healthcare field. De Ramon Fernandez A. et al. [10] declared that the management of the process is a powerful instrument for the redesign of clinical activities, thanks to the simplification of the workflow and the elimination of non-value-added tasks. In particular, process modeling is a support for a deep understanding of complex systems, that

otherwise could be very unclear. Mapping techniques are the cue for designing processes and subdividing them into phases and subphases [12]. Cozjnsen L. et al. [13] try to detect the reasons why industrial methods sometimes do not work in healthcare. They declared that industrial and business techniques can be used as an inspiration in the healthcare sector, taking into consideration the deep differences between the two sectors. Antonacci G. et al. [14] have proposed a systematic review in which the implementation of process management in the healthcare field is investigated. Despite its potential, the variance in reporting and the poor adherence to a principle often found in the healthcare field could compromise results. However, the application and reporting of process management are encouraged granting rigor.

The main aim of process management in the e-health sector is the organization and coordination of new types of activities. Szelagowski M. et al. [15] discussed the representation of clinical pathways as a communication tool among healthcare professionals, patients and caregivers, improving the quality of delivered services and reducing risks. Broekhuis M. et al. [16] represented the workflow process of stakeholders for help in the development of a telemedicine service. Despite significant improvements that have been achieved by working on processes in healthcare, there are still shortfalls in the existing techniques [17]. In particular, according to Ahmed E. S. et al. if flowchart is one of the most chosen methods in this context, it has been demonstrated to be abstract and poorly clear in complex domains.

In literature, other techniques are available for representing hospital and care processes. Integrated Definition for Function Modeling (IDEF) is one of the most known for defining processes [18]. It allows the description of the relationship between process and sub-processes and activities of each phase. Each activity is represented as a box, while arrows contain the objects related to each function (i.e. inputs, controls, outputs and mechanisms) [19]. Moreover, as described by Fu M. et al. [20], the logical relationship between operational tasks allows the transformation into Unified Modeling Language (UML) models for the creation of shared language. Although these diagrams are much appreciated in the industrial context, Bevilacqua M. et al. [21] have identified that IDEF0 is easy to learn, logical in its formulation and supported by computer programs easy to adopt also in health studies. Hence, they can be accepted also by non-professionals of the modeling techniques [22]. Also, Kammoun A. et al. [23] identified IDEF0 as an eligible method for the structured analysis and design techniques. However, this representation procedure is not still used for the evaluation of processes in which to introduce telemedicine solutions.

According to what was previously discussed, the present research aims at creating a methodology useful for a preliminary analysis of care processes chosen for the implementation of telemedicine services. The procedure for the acquisition of objective and complete information and the process representation based on the IDEF0 diagrams is presented as the starting point for the analysis of the efficient implementation of remote care techniques. In particular, an application study explains the AS-IS map process before the introduction of televisits in the heart failure clinic of the cardiac rehabilitation department of a large Italian hospital. The formalized information contained in the diagrams is the basis for discussions about the reorganization of the department activities

and a sustainable and continuative addition of remote care to conventional face-to-face visits.

3 Method and Tools

The adopted methodology is subdivided into four steps, as described in Fig. 1: collection of information about the process, representation of the process with IDEF0, check of preliminary mapping and discussion on the introduction of televisits.

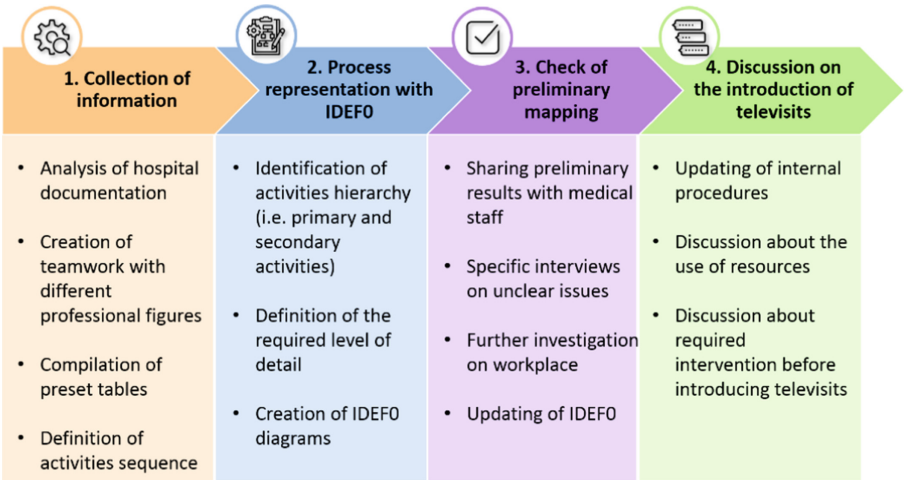

Fig. 1. Four main steps of the proposed methodology

In the first step, different information related to the examined process has to be collected. Initially, available internal procedures and protocols have been extrapolated from the hospital database. Formal documents about diagnostic and therapeutic care pathways of patients can be used to reconstruct the activities flow according to the different clinical situations. Additional details are extrapolated actively involving professional figures who daily perform care activities. A preliminary brainstorming allows the definition of the main phases of the process.

Some preset tables have been designed in order to facilitate the acquisition of knowledge intended for IDEF0 diagrams. Figure 2 (a) shows the structure of the grid, organized into five categories, following diagrams features: inputs, personnel and tools, performed activities, controls and outputs. Inputs section concerns activities carried out on patients, considering the hospital's point of view. In detail, inputs are mainly related to the identification of patients who receive actions from medical personnel. The patients' condition varies during different stages of the process (e.g. scheduled patient, examined patient, etc.). The second item has to be completed by adding the personnel involved during activities and the employed instrumentation. Even if physicians and nurses are the most present during the process, other professional figures included in single activities (e.g. biomedical engineers, other medical specialists) can be added. Moreover, the section

requires the distinction among informatic instrumentation (e.g. computers, software, web applications), medical equipment (e.g. electrocardiograph, oximeter, echo, etc.) and conventional tools (e.g. printer, written documents, telephone). The activities section is designed for the clarification of the medical and organizational work performed on patients by health professionals. In controls item, medical guidelines, national regulations and internal formal procedures required for the management of patients could be added. Finally, outputs help in specifying the outcomes of performed activities. Patients after receiving treatments and their updated documentation have to be considered.

Therefore, the medical personnel can work in a team and fill in preset tables, that guarantee uniformity and consistency in collecting knowledge. Consistent and unambiguous information is set up to be introduced in IDEF0 diagrams (Fig. 2 (b)). During additional focus groups, the involved personnel is asked to rewrite the information of tables on cards and create the real sequence of activities, attaching them to a wall.

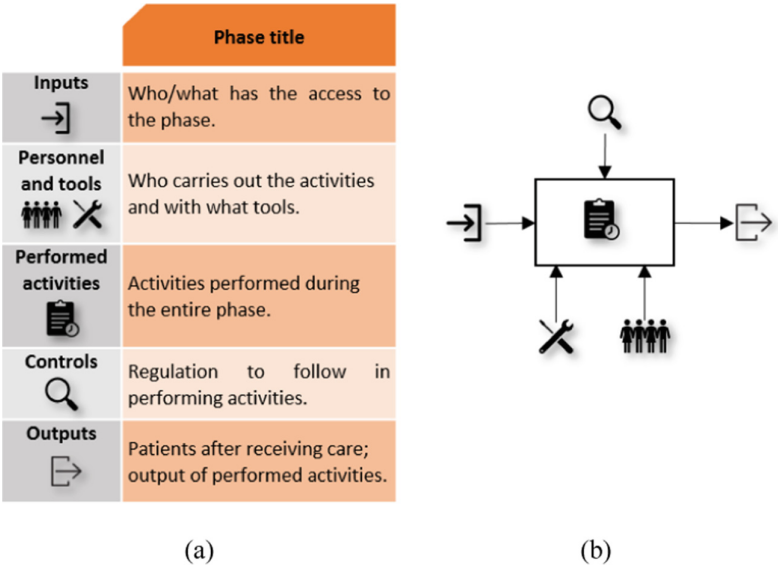

Fig. 2. Structure of table used for the acquisition of information (a) and its relationship with IDEF0 representation (b).

In the second step, data acquired with medical personnel is used to graphically represent the process under examination. IDEF0 diagrams have been chosen as one of the most suitable tools due to the variability and intricacy of activities required to cure patients. Indeed, IDEF0 facilitates the representation of complex processes [24]. In detail, they allow the hierarchical decomposition of the process into smaller parts and an easier separated description of each subsystem. First, the main activities of the process are represented. Then, a more detailed graphical description can be added for each primary activity. The most suitable level of detail can be chosen according to the specific situations. A tree node and a final glossary can be created and attached to the map for clearly declaring the process hierarchical structure.

During the third step, the draft version of IDEF0 is checked with the medical staff, who perfectly knows the activities, which they perform daily. Direct interviews permit a comparison of the correctness of sequence activities and the patient path within the process. Specific questions are created to fix those steps requiring a better understanding. Furthermore, the investigation of the workplace during each phase of the process offers the possibility for checking additional information. The clarification on the employed instrumentation, the workplace organization and the role of each professional is an additional stimulus for correcting and updating IDEF0 diagrams.

In the final step, the definitive representation of the process can be used as a base to discuss the method of activities execution in the clinic. Diagrams constitute a source for the updating of the internal documentation stored in hospitals. Thus, simplified diagrams concerning specific parts of the process can be extrapolated. Subsequently, they can be used for investigating the consumption of resources (i.e. personnel, technical instrumentation, money and time), underlying weaknesses and possible improvements. Furthermore, IDEF0 is the first step for discussing future improvements, as the reorganization of workspaces, activities and instruments for the efficient introduction of televisits as an alternative to ordinary care.

4 Application to a Case Study

The proposed methodology has been applied in the heart failure (HF) clinic of the cardiological rehabilitation department of the Italian hospital ASST Bergamo Est. An AS-IS map has been created with the IDEF0 technique for representing the process of caring for patients affected by HF, before the introduction of televisits.

4.1 Collection of Information

Documents related to the activities of the HF clinic have been extrapolated from the hospital database. Internal and external procedures have represented a useful source for detecting the organization adopted by medical personnel. The different typologies of monitoring and follow-up activities, which change according to the medical condition of patients, have been investigated. The documentation clarified the relationship between professional figures internal and external to the hospital. Members of the HF clinic have been involved in four meetings, scheduled to overcome the lack of information for an exhaustive understanding of the process. The teamwork included all professional figures taking part in the process: doctors, nurses and a physiotherapist. Theoretical lessons about process modeling have been combined with more practical activities. During meetings, four main phases have been identified as the core of the care process, as represented in Fig. 3: patient's access to HF clinic, performing of first medical examination, monitoring and performing follow-up examinations and activities. The use of preset tables helped in the strategic collection of knowledge useful for the following graphical representation of the process. Thereafter, details collected in the table have been rewritten on cards, and the flow of activities has been discussed with the medical personnel.

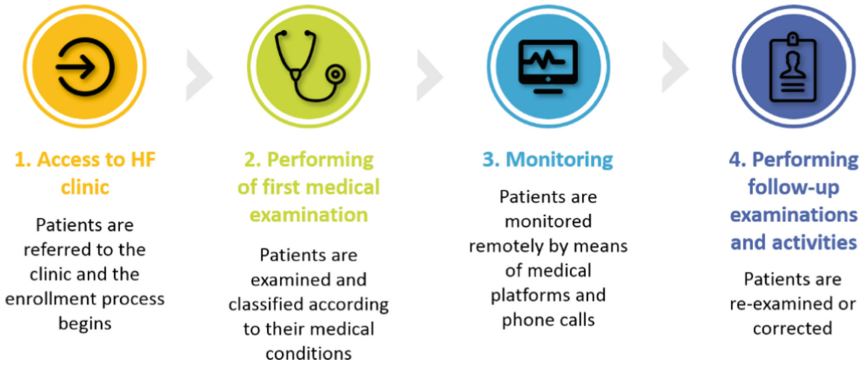

Fig. 3. Four main phases of the process of caring for patients with HF.

4.2 Representation of Process with IDEF0

According to the data collected in the previous phase, the process has been subdivided into four hierarchical levels. Figure 4 represents the general structure of IDEF0 diagrams.

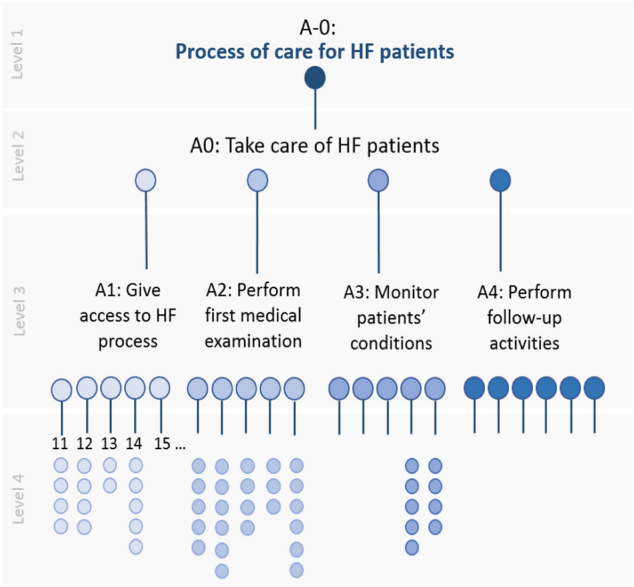

Fig. 4. Hierarchical levels of the process.

The A-0 layer summarizes the most general information about the process of care for HF patients. The four main phases of the process have been converted to infinitive verbs and introduced inside activity blocks of the A0 level. Hence, each of them has been specified in sub-levels (A1, A2, A3, A4), useful to better investigate more aspects. These layers contained between 4 and 6 activities; each of them has been further examined

(A11, A12, A13, etc.). According to this particular application, special attention has been turned to the identification of roles and the employed instrumentations. Some activities were not included in the fourth level because an acceptable detail level had been already reached.

4.3 Check of Preliminary Mapping

The check of IDEF0 diagrams has been subdivided into two separate moments. In the first step, results of a preliminary mapping have been presented and discussed with the medical teamwork during additional meetings. Possible modeling errors and misunderstandings have been directly clarified and updated on graphs. This has allowed the staff to integrate different points of view and to agree on a final common version. Moreover, during meetings health professionals have understood how to read and interpret IDEF0 diagrams. In the second step, the in-person checking on the actual workplace allowed monitoring of real activities carried out during the entire process, such as the first medical examination, the monitoring and the delivery of follow-up activities. The observation of doctors' and nurses' actions during their daily work constitutes a complementary source of information, sometimes more detailed than what has been collected during meetings. The combination of the two moments contributes to create clearer and more complete final IDEF0 diagrams.

4.4 Discussion on the Introduction of Televisits

The final IDEF0 version has been shared again with the medical team, to exhibit found results and offer a source of discussion. Weaknesses and criticalities found during the care process have been highlighted and analyzed with professional figures. The updated diagrams and their contents have been used as a starting point for understanding the AS-IS situation. Hospital documents have been updated with written procedures and simplified flowcharts. According to the new information, next steps required for a better introduction of new telemedicine care services could be hypothesized and planned. The organization setting and the involved personnel during a televisit section can be designed and compared with the actual resource consumption.

5 Discussions

Process modeling techniques are not new in hospital scenarios. However, the proposed methodology offers a different approach, customized for studying care processes in which integrate telemedicine services. The employment of structured tables intended for the well-ordered investigation of information, combined with the use of IDEF0 diagrams, has allowed the detection of critical aspects that, if not properly managed, could compromise the effectiveness and efficacy of telemedicine applications.

In the present case study, IDEF0 representation has revealed the presence of two principal issues, to be solved before the introduction of televisits in the HF clinic. First, a portion of documents related to patients' history (i.e. registered medical prescriptions, examinations, or medical reports) is still based on paper documents. The presence of a

physical database limits the information sharing and it is not suitable for the planned introduction of televisits. Supplementary printed copies create waste; they increase the workload of medical personnel and the management of the storage. The employment of digital medical folders allows the fast sharing of information among patients, health providers and the database by means of platforms and mobile applications. The possibility to share medical reports, examinations and other types of information is the base for effective employment of digital care.

The second issue concerns the fragmentation of activities due to the use of a lot of different software and applications. In particular, the work of the medical personnel is subjected to human errors and eventually overburdening because of the simultaneous use of many applications not communicating with each other. Accordingly, the addition of one more platform for televisits would increase the workload of physicians and nurses. On the other hand, a leaner system with an integrated and communicating system of applications would imply higher efficiency, reducing the time spent and improving the mood of healthcare professionals. Moreover, the availability of quiet rooms dedicated to televisits with high-quality instrumentation (i.e. computers, audio headphones, webcams) implies the reorganization of the conventional in-presence visiting rooms.

The choice of the IDEF0 technique represents an unconventional aspect in the healthcare field. Its employment has allowed the complexity reduction of the care process by means of the differentiation of the main phases and their sublevels. Otherwise, the definition of the right and complete flow of activities would be very complicated also for personnel who is daily involved in the care process. Even if far from the medical background, IDEF0 has been crucial for the effective extrapolation of a high amount of information. The employment of preset tables represents an innovative aspect, useful for discerning and collecting only the information required for the diagrams, neglecting the less significant ones. Tables have offered health personnel a guide for neatly describing activities of the process. The basic training provided the skills required to read diagrams and to extract the required pieces of information. Moreover, preset tables have facilitated the medical team in reading and interpreting IDEF0 by themselves, so that they could be easily understood.

IDEF0 has created a common and systematized language for the description of processes in which introduce televisits. The representation has permitted the definition of formalized knowledge inside hospitals, in which information is usually fragmented. Hence, health professionals may exploit the final representation as a base for updating written procedures, ensuring a better adhesion to actual practices and discussing the implementation of new digital solutions.

6 Conclusion

The present research proposes a methodology, related to hospital processes intended for the introduction of telemedicine services. The approach allows the knowledge collection and process representation for a deep detection of activities organization, involved personnel and resources consumption.

The methodology is subdivided into four steps. The procedure for the acquisition of data about health providers' activities plays a crucial role in the effective representation

of the process; it is proposed basing on preset and standard tables. Then, the placement of tables information in IDEF0 diagrams is presented. The preliminary draft of the process has to be checked and shared with the involved medical personnel. The final version is used by health professionals as a base for the discussion about the AS-IS situations and future implementations.

The application of the four steps in the HF clinic of a large hospital in Italy is proposed. The mapping of the ordinary AS-IS process before the introduction of televisits is a strategic preliminary operation, useful for the investigation of strengths and weaknesses of the actual treatment procedure. According to the found considerations, the process can be improved or redesigned, in order to offer higher quality services to patients. In particular, the streamlining of activities will be possible by means of adequate technical equipment based on a few computer applications, able to communicate one to each other. Moreover, the reorganization of activities and digitalization of documents could further simplify future implementations. The emerged critical issues have been discussed with medical personnel and hospital managers, as a starting point to set the stage for adding telemedicine services.

A solid and controlled process of care is the basis for a more efficient and durable integration of digital care; moreover, it helps the involved professional figures in acquiring consciousness about the complete flow of activities and increase their outcome. Future researches could replicate the proposed methodology by integrating the option of digital care. The mapping will offer a document for the detection of the variation of employed personnel and resources in the two different situations. An evaluation of reached improvements with the adoption of telemedicine services could be performed, by considering both hospitals' and patients' points of view.

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