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A Business Process Model for Integrated Home Care

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Abstract

Currently, Integrated Home Care (IHC) represents a good alternative for providing health and social care but, even if several research efforts have been made, the complexity of the domain implies further investigation. In particular, the lack of precision in defining activities, actors involved and goals have led some European countries including Italy to have low levels of coordination and integration of care delivery. In order to tackle this issue, this paper presents an analysis on existing IHC processes in Italy and, starting from the results of such an analysis, proposes an IHC process model represented by using the Business Process Model and Notation (BPMN). The choice of BPMN relies on its flexibility that makes it preferable if compared to other similar languages. Indeed, it offers two levels of representation: the graphical notation, that makes it simple to understand, and modeling constructs to represent the message-based interactions and the event-based decisions, and then relevant features such as dynamics. Additionally, such a modeling allows early detection and resolution of critical issues. This work can be an essential previous step for further analysis and improvements of IHC processes, including the adoption of ICT.

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Keywords: Process modeling in healthcare; Integrated Home Care (IHC); Business Process Model and Notation (BPMN)

1. Introduction

In recent years, many European countries have been facing weighty problems about healthcare services, such as the increasing prevalence of disability and chronic diseases, the ageing of the population, the lack of inpatient beds, etc. These problems have exacerbated the need to decentralize healthcare, leading to a shift from in hospital care to home care, by reducing hospitalization costs[1]. For these reasons, home care is a good alternative for giving health and

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social care but, even if several research efforts have been made, the complexity of the domain implies further investigation[2,3]. However, currently, a worldwide uniform definition as well as a standard model of home care do not exist, causing that the offered services differ across countries and in diverse areas of a same country. The lack of precision in defining activities, actors involved and goals and the diffusion of heterogeneous applications have led some European countries including Italy to have low levels of coordination and integration of care delivery[1].

In this work, we will refer to home care with the term Integrated Home Care (hereafter, IHC). According to that reported by Larsen et al.[4] as well as to the document of the Ministry of Health in Italy[14], IHC takes place in the patient's home as part of an integrated care pathway among primary care, hospital and social services for patients with specific health and social needs and it is performed by a multidisciplinary team in collaboration with the patient at home.

Nowadays, the use of Information and Communication Technology (hereafter, ICT) is increasingly seen as a solution to enhance efficiency, quality, coordination and integration of the care delivery within the IHC. The main problem, however, is not represented by the lack of ICT but, rather, it has to be clarified as to how to effectively exploit ICT within the IHC domain. In order to develop and implement ICT solutions for the IHC domain, it is essential for developers and care professionals to fully know and understand the IHC that, in general, can be seen as a process with inputs, outputs and purposes involving entities that perform acts subjected to constraints. The knowledge about IHC as a process can allow, in fact, the understanding of work procedures and flows, information demands and exchange, people and resources involved, roles and responsibilities before ICT development is initiated[1,5,6].

All of these considerations represent the rationale of this work. In particular, a unique and standard model enabling a general understanding of the IHC process is needed in order to implement, in the future, an efficient integrated ICT system offering IHC services able to grant adequate levels of efficacy, effectiveness and best practice[3]. In order to achieve this goal, this paper proposes, as a technical solution, a business process modeling approach to build a general IHC process model[7,8]. In more detail, a deep analysis on existing IHC processes in Italy has been preliminarily carried out. Successively, starting from the results of this analysis, an IHC process model has been defined and represented by using Business Process Model and Notation (hereafter, BPMN)[10]. Such a model has been broken down in sub-processes in order to face the high complexity of the IHC domain. In each sub-process, different actors, who perform several actions in a coordinated and joined way, have been considered, highlighting especially the message-based interactions and representing the decisions that are based on events.

The rest of the paper is organized as follows. Section 2 presents related work, whereas Section 3 describes the analysis describing some relevant IHC models existing in Italy. Section 4 introduces the modeling approach used and formalizes the IHC model. Finally, Section 5 presents a discussion concerning the implications of the method used for modeling the IHC process.

2. Related work

Computerization of healthcare processes in general, and of the IHC in particular, represents a critical research area. The majority of research focuses only on some issues of the IHC domain and does not meet the entire subject.

In more detail, Arbaoui et al.[3] introduced the concept of a Home Healthcare (hereafter, HH) support system. They adopted a process approach to deal with the HH domain in order to underline the importance of the organizational aspects and examine the requirements to be met by such systems to support ICT-based HH projects. However, they leave out an important characteristic such as the decentralization of the activities, where different actors are involved and their cooperation and coordination are needed to achieve the high quality of the HH. Besides, they did not address the issue that HH processes integrate heterogeneous sub-services and involve several organizations.

Lanzarone et al.[11] focused on decision-making models to manage organizational activities, including the assignment of operators to patients, and to predict patients' demand evolution. However, their work showed that an acceptable level of continuity of care can not be attained without modeling continuity of care as a hard constraint.

In 2010, Valls et al.[12] proposed the use of the ontological paradigm to describe the organizational knowledge of a complex healthcare institution as a basis to support their management.

Matta et al.[6] followed a process modeling approach, by formalizing their framework in an IDEF0 (Integrated Definition for Function Modelling) activity-based model in order to describe the most relevant clinical, logistical and organizational processes associated with HC operations. However, they provided only a static representation of an HC organization. In fact, IDEF0 is unable to represent system dynamics such as those occurring in IHC process.

Rabbi et al.[23] proposed a linguistic extension to the metamodeling hierarchy, in order to model the integration of different aspects of a healthcare information system. However, they did not metamodel all the features.

To evaluate usability and utility of some modeling methods, Jun et al.[7] presented a study of eight modeling methods, chosen to represent most of the functions of process modeling. Particularly, some methods, such as communication diagrams for understanding interactions, swim lane activity diagrams for modeling roles, state transition diagrams for giving a patient-centered view, were considered to be helpful in comprehending certain aspects of complex processes.

Instead, Muller et al.[9] argued that BPMN is suitable for the healthcare domain, even though there exist some deficits concerning roles and task assignment. In this regard, they proposed to incorporate role information in process models using the color attribute of tasks as a complementary visualization of the usage of lanes. However, in this way the advantage of displaying the information flow is lost.

However, in a multidisciplinary and multidimensional process, such as the IHC, where the patient is managed by a team of different care professionals and where usual meetings between diverse actors rarely occur, coordination and interaction constitute key features to be faced. Then, a business process modeling approach aimed at highlighting and representing the interactions from a dynamic perspective rather than by taking only into account the local behavior of individual actors involved in the IHC is needed. Summarizing, all these considerations represent the rationale for the business process model, based on BPMN collaboration diagrams, that has been proposed in this work.

3. The analysis of IHC processes in Italy

IHC is still a "young" service in the network of social and health services in Italy. Its organization has been scarcely investigated and it is still far from having important standardized reference models. Indeed, its spread is still inadequate. Italian Regions, and also different local authorities and municipalities inside a Region, differ in terms of both the sub-processes underpinning IHC and the professionals involved.

For this reason, the state-of-the-art situation of IHC in Italy was analyzed by studying the IHC process of eight Italian Regions, according to that reported in different regional guidelines[15,16,17,18,19,20,21,22]. This study was finalized to identify common actors and activities among the different regions and highlight critical issues that, according to us, should be clarified and solved in order to provide a unique and general IHC process model which summarizes them all and that, in the future, will allow us to develop an information model for the IHC domain according to current international standards. The criteria used to evaluate and compare the different IHC processes were: i) actors involved and their roles played in the different activities; ii) specific actions and their sequence; iii) important decision points; iv) interactions between activities and actors involved in the process; v) management systems, tools and methods used for the coordination of activities.

A summary of the findings of this analysis is reported in Table 1, where, for the sake of brevity, only four processes, which we consider as most significant, are reported.

Table 1. Mapping of IHC processes existing in Italy (where GP: General Practitioner; LHU: Local Health Unit; IEU: Integrated Evaluation Unit; SC: Supply Company; ICP: Individual Care Plan; SP: Specialist Physician; SAP: Single Access Point; CM: Case Manager; OUD: Operative Unit District; OCD: Operative Core District; DM: District Manager; SS: Social Services; DD: Director District.)

Criteria	process 1	process 2	process 3	process 4
Actors and roles	• GP: activation request. • LHU: activation; first level evaluation. • IEU: multidimensional second level evaluation; profiling; voucher assignment; re-evaluation. • SC: taking charge; ICP definition; changes evaluation; control of care effectiveness; discharge.	• GP: activation request. • SAP: activation; first level evaluation; activation IEU and OUD. • IEU: multidimensional evaluation; definition ICP; periodic and final checks and evaluations of ICP; assignment CM; discharge. • CM: planned activities monitoring. • OUD: care provision management. • OCD: care provision.	• SAP: initial acceptance; preliminary evaluation; activation IEU • IEU: social-health evaluation; ICP definition; family support evaluation; CM assignment; team care assignment; periodical re-evaluation • DM: activation request receipt; care plan relevancy evaluation; Care Plan underwriting. • Team care: care provision.	• GP/OUD: complex needs detection; health evaluation; admission proposal. • SS: complex needs detection; social evaluation; admission proposal. • DD: IEU activation. • IEU: multidimensional evaluation; IHC activation; ICP definition, verification and updating; • Team care: care provision. • Caregiver: 24/24h care.

Actions and sequence	1) IHC activation request. 2) First level evaluation. 3) Multidimensional evaluation. 4) Care profiling. 5) Voucher assignment. 6) SC choice. 7) Patient taking charge. 8) ICP definition. 9) Care Provision. 10) Changes control. 11) Care effectiveness control. 12) Discharge.	1) IHC activation request. 2) First evaluation. 3) Multidimensional evaluation. 4) ICP definition. 5) CM assignment. 6) OUD activation. 7) OCD activation. 8) Care Provision. 9) Re-evaluation. 10) Discharge.	1) Problem reporting. 2) Initial acceptance. 3) Preliminary evaluation. 4) IEU activation. 5) Multidimensional evaluation. 6) Draft ICP definition. 7) IHC activation request. 8) Relevancy ICP evaluation 9) Care plan underwriting. 10) Drugs delivery. 11) Care provision. 12) Discharge. 13) Data storage.	1) Admission request. 2) First level evaluation. 3) Admission proposal. 4) IEU activation. 5) Multidimensional evaluation. 6) IHC service activation. 7) ICP definition. 8) Care Provision. 9) ICP monitoring and evaluation. 10) Multidimensional re-evaluation. 11) Discharge.
Decision point	• Complex needs detection. • Conditions change detection. • Effective care.	• Complex needs detection. • Results re-evaluation. • Conditions change detection.	• Complex needs detection. • Multidimensional evaluation results. • Relevancy care plan. • Change conditions.	• Complex needs detection. • Multidimensional evaluation results.
Interactions	• between GP and LHU, during activation request. • SC refers to IEU for multidimensional re-evaluation, when conditions change and during effectiveness care control.	• between SAP and Patient, municipality, Hospital or GP during activation request. • between SAP and IEU, during admission step • between SAP and OUD, during care activation	• between SAP and Patient, during initial acceptance. • between SAP and IEU, after preliminary evaluation. • between IEU and DM during activation step.	• between GP/OUD/SS and Patient, initial acceptance. • between GP/UOD/SS and DD, admission proposal. • between DD and IEU, after admission proposal. • between IEU and CM during ICP monitoring.
Tools	Care diary	Records with care diary	Records	Care diary

Starting from the findings reported in Table 1, it is possible to note that these different processes share some basic common aspects. As a consequence, a common IHC process can be defined, from a more general perspective, as composed of many sub-processes, namely Admission, Multi-Dimensional Evaluation, Individual Care Plan Definition, Care Provision and Re-Evaluation[13], which are represented in Fig. 1 (a). It can be executed several times, until the achievement of proper results with the patient's discharge.

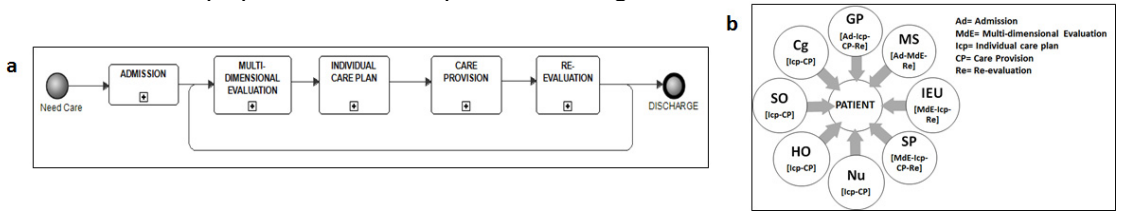

Fig. 1. (a) IHC general process in Italy; (b) Actors involved in the provision of IHC services in Italy.

In all the models examined, we identified the interacting actors reported in Fig. 1(b), where the Patient is placed at the center, and the rest of the actors, with their involvement in the several steps of the IHC process, is arranged around it. In detail, the typical **Patient** is a person with diseases and disabilities that limit his/her cognitive and physical capabilities. The **General Practitioner (GP)** is the physician who is in charge of the patient. He/she provides primary contact. The GP requires the patient admission into IHC service indicating patient's problems and conditions. The GP is usually assigned as Case Manager (CM) and, then, follows the evolution of the patient by periodically performing follow-up, scheduling and supervising activities of the IHC Team members. The **Integrated Evaluation Unit (IEU)** is a multidisciplinary team that assesses the problems, defines an ICP, evaluates the results and verifies the achievement of the goals. The IEU selects the professional figures to perform the ICP. For patients with particularly complex medical needs, IEU can require consultation of a specialist physician. The **IHC Manager Service (MS)** is responsible for the administrative and organizational IHC service. In fact, he/she organizes and schedules the general activity, manages the personnel, selects the IEU members, manages the relationships between the patient, GP and IEU. The **Specialist Physician (SP)** is a medical doctor specialized in one branch of medicine. He/she can both treat

diseases and act as a consultant to other physicians. The **Health Operator (HO)** operates to restore or enhance the abilities of the patient. The most frequently employed sorts of HOs are Physical and/or Speech Therapists. The **Nurse (Nu)** is the provider of general nursing care. The **Social Operator (SO)** represents the operative branch to support social needs, with special regard to Activities of Daily Living. The **Caregiver (Cg)** is in charge of the continuous care of the patient, usually 24 hours a day.

After depicting the common aspects of the four processes cited, it is worth highlighting that many differences are present in the Admission, Multidimensional Evaluation and definition ICP steps, particularly, in the activation mode. For example, in some models, such as models 1, 2 and 3, it is performed by LHU or SAP after receiving the activation request. In the model 4, instead, the preliminary evaluation is carried out separately by GP for the health part and by SS for the social part. Another difference regards the definition of the ICP phase. In model 1, in fact, ICP is defined by SC according to the profiling performed by IEU, whereas, in the other models, ICP is defined directly by IEU.

Instead, the greatest deficiencies are present in the Care Provision and Re-Evaluation phases, particularly during the handling of variations of the patient's conditions. For example, according to the model 1, whenever there is a change in the patient's condition, even minimal, the IEU is reconvened and, again, a Multidimensional Evaluation is made. In the model 2, instead, there is not specific mention about how, what and with whom the operating team has to communicate or what it has to do in case of changes. Really, in the model 3, the Care Provision is not explained and the Re-Evaluation step is completely absent. In the model 4, the periodical Re-Evaluation phase is present but it does not take into account how to handle variations of the patient's condition. Furthermore, the consultation and collaboration of a Specialist Physician could be required during the Care Provision and Re-Evaluation steps. However, none of the processes analyzed refers to such an eventuality.

4. The formalization of a general IHC process model

As a consequence of this analysis, it appears clear that the Italian IHC domain is characterized by a complex and heterogeneous set of processes, differently actuated in the various Regions and based upon synergic actions of the aforementioned actors. Furthermore, the organization appears strongly distributed and, then, the various professional figures involved rarely meet each other and the flow of information is neither constant nor complete.

Therefore, a business process model of IHC processes for the Italian domain has been proposed, including actors involved, their activities and interactions, with the final aim of integrating common elements of the models aforementioned as well as solving the critical issues previously identified. It has been realized according to a business process modeling approach by using the BPMN standard. This methodology provides mechanisms to model business processes, with a graphical notation to better understand their internal procedures, and gives the ability to communicate these procedures in a standard way[10]. The choice of BPMN was based on its flexibility that makes it preferable if compared to other similar languages such as UML activity diagrams and IDEF0[6,7,9]. Indeed, it offers two levels of representation: the graphical notation, that makes it simple to understand, and modeling constructs to represent the message-based interactions and the events-based decisions.

In detail, the proposed model has been defined as a collection of five sub-processes contained into a Collaboration diagram. In BPMN, such a diagram models Collaborations, which are collections of Participants shown as Pools, whereas their interactions are shown by Message Flows, and may include Processes within the Pools. Such a way it has been possible to describe all entities of a process and, plus, also the message flows between pools, which are used to exchange data and coordinate work between collaborating participants. Besides, the use of constructs such as the gateways (i.e. inclusive, exclusive, event-based and parallel) has enabled to control different types of Sequence Flow behavior, such as decisions/branching, merging, forking, and joining.

In the Collaboration diagram, the nine actors above described have been classified as "participants" and modeled with dedicated pools in order to highlight the interactions among them within a single sub-process or among different sub-processes. For the sake of brevity, the textual description of all the five sub-processes is extensively outlined in the following, whereas only the BPMN representation of two sub-processes, which, according to us, are the most complex and relevant, is reported, i.e. Care Provision and Re-evaluation.

In the first sub-process, i.e. Admission of the patient, the Patient reports to his/her own GP the need of supportive care. The GP is the physician who provides primary contact and requires the intervention of IHC service. The SM is the figure who receives the admission request by the GP and assesses the relevance of information reported in the admission request. After sending the IHC admission request to the SM, the GP waits for three different events that

could happen next: i) the request is evaluated as pertinent and, then, the admission request is accepted; ii) the information is insufficient and, then, the SM asks the GP to integrate the request; iii) the request is evaluated as non-pertinent and non-relevant and, then, the admission request is rejected. In this case, an *event-based gateway* was used to model the situation where the GP waits for a response. It is a branching point where the alternative paths following it are based on events that occur, rather than on expressions to evaluate (as with *exclusive* or *inclusive* gateways).

In the second sub-process, i.e. Multi-Dimensional Evaluation, the SM assigns the members to constitute the IEU. Each member of the IEU receives the assignment and confirms the participation to the SM. After, a *parallel gateway* has been used to indicate that the IEU can perform two activities concurrently, rather than sequentially. Particularly, the IEU can collect the patient's existing information and, contemporarily, can make the Multi-Dimensional Evaluation interviewing the patient and receiving the necessary information. At this point, we have used an *exclusive gateway* to indicate that only one of the two branches can be traversed: i) in case of insufficient information, the IEU can require the consultation of a SP; ii) in case of sufficient information, the Multi-Dimensional Evaluation finishes. In the "Individual Care Plan" sub-process, the IEU defines the ICP and sends it to the GP. At this point, the IEU waits for two different events: i) the IEU receives an agreement by the GP; ii) the plan is considered irrelevant and, then, the GP asks the IEU to integrate the plan. Also in this case an *event-based gateway* has been used to indicate that the IEU waits for a response. After the IEU assigns the CM and, then, selects the members of the Team. Finally, the IEU sends the names of the IHC team members to the CM. Once the ICP has been defined and sent to the GP, this latter starts the following sub-process, as shown in Fig. 2. The GP/CM organizes the activities and sends the interventions scheduled to all the operators of the IHC Team. These ones, after receiving the intervention program, will perform only interventions of their competence. In order to resolve the issue concerning the handling of variations of the patient's conditions, an *inclusive gateway* has been adopted to indicate that each operator always records the interventions performed on a specific interventions diary, while the send task "Report conditions modified" is performed only if the patient's conditions or needs change. Contextually the GP/CM, after notifying the interventions scheduled to each operator, performs and records his/her interventions scheduled, and simultaneously controls the performance of the scheduled activities, receiving the record of interventions performed by each operator. Another *inclusive gateway* has been applied after the send task "Notify interventions scheduled" to indicate that the first branch

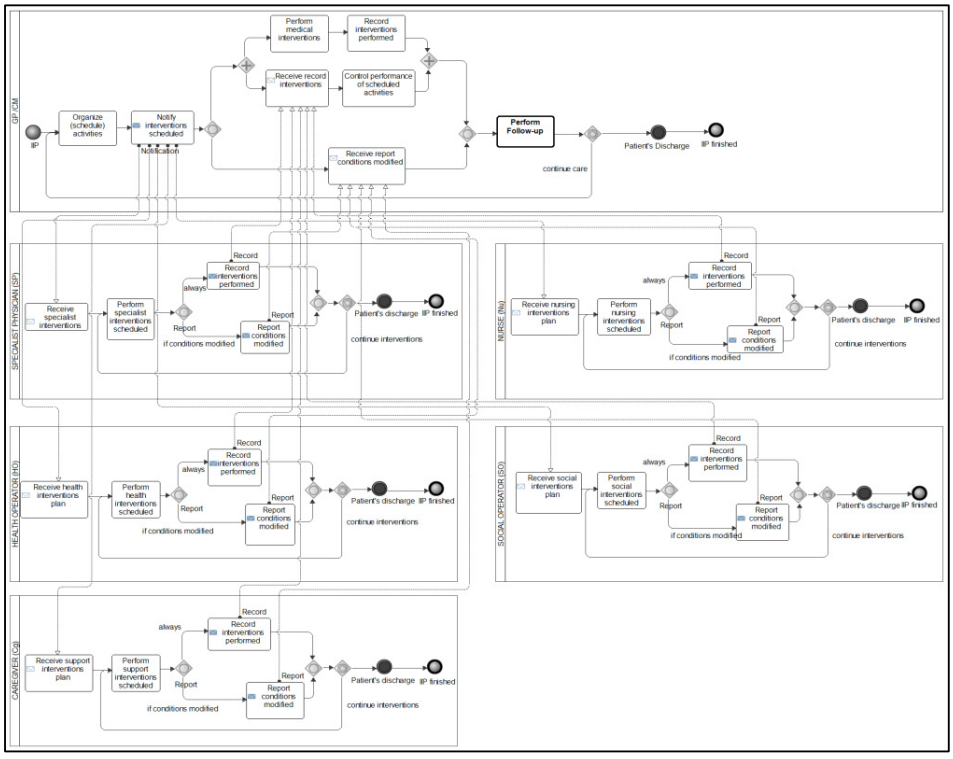

Fig. 2. Care Provision

is always executed, while the receive task "Receive Report conditions modified" is performed only if modifications in the patient's conditions arise. After the inclusive gateway, the task "Perform Follow-up" is depicted with a *collapsed call activity*. In this case, the "Perform Follow-up" is not a sub-process of "Care Provision", but it is an independent process represented in "Re-Evaluation", such as shown in Fig. 3, and that is re-used within the "Care Provision". The participants, by means of an *event-based gateway*, continue interventions until the event patient's discharge occurs.

In the last sub-process shown in Fig. 3, the GP performs the follow-up, according to the point in time of evaluation defined in the ICP. If the patient's status is not modified, the GP/CM simply reports the follow-up's observations, otherwise he/she has to evaluate what to do: i) to ignore the report, prescribe further clinical/diagnostic examinations and/or require specialist consultation; ii) to request a multidimensional re-evaluation. In the latter case, the IEU receives the re-evaluation request and, through a *parallel gateway*, simultaneously examines the reports' follow-up and proceeds to the assessment of the problem by means of a *collapsed call activity*. Next, the IEU decides if to discharge the patient or to continue the care defining a new ICP.

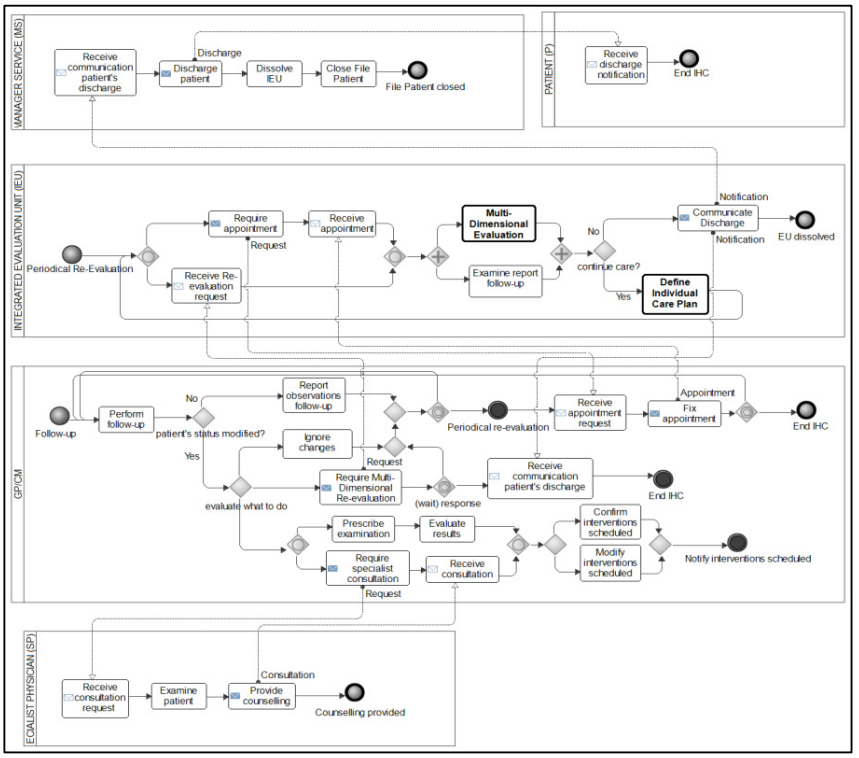

Fig. 3. Re-Evaluation

5. Discussion and conclusion

Definition and formalization of care processes are important steps for all organizations providing services to the person. In fact, they enable the improvement of understanding and organization of healthcare processes. Modeling processes pertaining the IHC domain, in particular in Italy, is a very thorny task, since it is very heterogeneous, differently actuated in the various Regions, and strongly dynamic, with a distributed organization where different professional figures are involved, with rare physical meetings and a variable and incomplete flow of information.

In order to provide a unique and common representation of IHC processes, a business process modeling approach was adopted. First a deep analysis on existing models of IHC processes in Italy was carried out, identifying many common elements as well as some critical issues to be solved. Successively, starting from the results of this analysis, a novel business process model was defined, including actors involved, their activities and interactions, and represented by using BPMN Collaboration Diagrams. In such a way, the interactions between different actors and the change of control flow between them were explicitly and clearly expressed in accordance with a dynamic vision,

which is essential in a multidisciplinary and multidimensional organizational process such as the IHC one. Moreover, all entities involved in the IHC process were considered and modeled, together with the message flows between pools, which were used to exchange data and coordinate work between collaborating participants. Due to the expressiveness of BPMN, the proposed IHC process model was thought to be understandable for both modelers and users, enabling the representation of both static and dynamic aspects. Additionally, such a modeling allowed early detection and resolution of critical issues.

The model we have developed does not claim to be a better model than others. Instead, its main aim is to provide a unique and general model that summarizes them by taking into account the several guidelines of different Italian regions. This work represents an essential preliminary step for further analysis and improvements in IHC processes, including the implementation in some local realities and a full adoption of ICT.

However, BPMN is constrained to support only the modeling of business processes. Other types of modeling, for instance data modeling, are out of the scope of BPMN. For this reason, as a future work, the proposed business process model will be integrated with an information model for the IHC domain, which will be realized by using the current international healthcare informatics standards, such as HL7 RIM.

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