A modeling framework for an innovative e-health service: the Hospital at Home

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Abstract. This paper explores a modeling and simulation framework in healthcare following a process-centric approach. We focus on an innovative hospital service, Hospital at Home. The framework introduces a business process analysis to detect weakness and bottlenecks, including simulation to perform scenario analysis and the integration to e-Health solutions. The aim is to investigate the role of technological innovations as telemedicine and televisiting in order to explore the impact on both patient well-being and business process management. This work provides an overview of the functioning of the actual process. The outcome of the here proposed framework allows hospital managers to evaluate the extension of this kind of healthcare service, e.g. to other hospital departments or territorial contexts. The direct and positive impact of assistive technologies on the quality of life of patients, has an impact on the overall management of the organizational processes. First, we describe how this kind of service, its presence on the territory, its adaptability and the interaction with telemedicine improves benefits both for patients and operators. Second, we discuss how the approach is suitable to be applied in case of emergency situation, e.g. COVID-19.

Keywords: e-Health · Telemedicine · Covid-19 · Business Process Management and Simulation.

1 Introduction

In recent years, the attention is increasingly focused on integrating the typical hospital service model to alternatives care due to the increasing ageing of population. This leads in relevance to models of home care and focused on the needs of patients often suffering from multiple chronic diseases [27, 4]. Home hospitalization model and technological solutions have demonstrated a positive impact on health, well-being and quality of life [33, 21, 3]. In particular, assistive technologies focus on the concepts of patient-centered care, which is actually worldwide recognized as an essential dimension for the quality of care, as well as

the so-called patient empowerment. A recent literature review about the topic reveals how a great amount of articles focuses on technology applications to all knowledge areas of health, as in the case of patient education or medical information management [11, 2, 32, 8]. From an organizational perspective, Business Processes Management and Simulations address healthcare managers to better allocate appropriate resources or to improve the responsiveness of care to patients [24, 23, 15].

As a use case, this work explores the results of a large project [3] having the aim to analyse technological applications in different hospital wards (geriatrics, pneumology, neurology, physiotherapy) thanks to the application of Artificial Intelligence (AI), integrated devices and machine learning algorithms to e-Health software [30]. In this work, we will focus on the application of innovative telemedicine technologies and documents digitalization to supporting the care of elderly patients in the context of a Hospital at Home (HaH) for acute pathologies or exacerbation of chronic pathologies. We adopted a multi-disciplinary vision of the patient care service to increase the skills and competencies of caregivers/patients, by rationalizing health processes, and the management of economic resources.

Furthermore, during this pandemic period, HaH has been integrated with telemedicine technologies as part of a clinical study (henceforth TELEMACO). Here the attention includes telemedicine to monitor COVID-19 positive patients at home quarantine. In particular, the Hospital at Home Service is provided for more vulnerable patients, i.e. the elderly [22, 35, 26]. Following the proposals of Italian Ministries of Health and Technological Innovation and Digitisation[4] HaH aims to systematically use telemedicine and new technologies to monitor at home elderly patients suspected to be COVID-19 or discharged from hospital wards diagnosed with COVID-19 but not requiring intensive/invasive monitoring, containing the risk of contagion. Finally, from a software engineering perspective, the attention to business strategies and software development has to be integrated with users' concerns, as in the framework of a Human-Centered Design [17].

This paper is an extended version of the article [9]. In this work we show how the generators of the simulation are made, the dataset, the detail of the simulation and not only the expected results but the results of the simulation for the As-Is and the To-Be model. The remainder of this paper is structured as follows In Section 2, we introduce our methodology. In Section 3, we contextualize the HaH service case of study, its process and its business simulation and the results of improvement made by e-Health device. In the Section 4, we show the applicability of this telemedicine model in the "COVID era". Section 5 provides some remarks and considerations about future work.

[3] The current work discuss the project "La CAsa nel Parco" (CANP) in the Italian Regione Piemonte, supported by European funds. See website of the project: http://casanelparco-project.it/

[4] See Program "Innova per l'Italia" https://innovazione.gov.it/innova-per-l-Italia-la-tecnologia-e-l-innovazione-in-campo-contro-l-emergenza-covid-19/

2 Methodological framework

The here presented framework involves three different stages:

- **The analysis of the context**: it aims to understand what the actual situation is and what could be the needs for improvements at different levels.
- **The creation of the HaH As-Is model**:
  - On one side, **the business process analysis** examines the actual situation of the organization in order to create the As-Is model of the process, then **the simulation** is useful to validate the model thanks to some performance indicators.
  - On the other side, **the user experience (UX)** research with patients, caregivers, and hospital professionals leading to a detailed understanding of the context (As-Is), the definition of user requirements, and opportunities for innovative solutions.
- **The introduction of e-Health technologies**: these kind of technological applications improves the healthcare process. In particular, we investigate some devices for telemedicine and a prototype applications aimed at helping the staff with the management of visitors tour.
- **The re-engineering and scenario analysis**: the purpose is the optimization of the process proposing different configurations in a *what-if* analysis.

A. The Business Process Analysis and Simulation. In order to analyse the business processes of the hospital at home service, we exploit a Business Process Management (BPM) methodology that has, as one of the main issues, change management [14, 1]. In order to adopt a process-centric approach, to describe the diagram of the process we will use the Business Process Model and Notations (BPMN) standard language [13, 5]. This language acquires a particular consideration also in the context of healthcare studies due to the readability for stakeholders [8, 28, 25]. The business process analysis aims to define and engineer a visual model of processes (i.e., process map or flowchart). This first As-Is model represent the actual situation of the business process and the diagrams show the sequence of activities and various crossroads (gateways), which lead to different routes depending on choices made. For the purpose of the simulation it is possible to integrate in each activities other information as resources that perform the activities, their characteristics (capability, schedules, costs), the execution time of the activities, policy management, and the realistic work-load. In this way, the simulation allow to obtain an evaluation of the performance indicators based on which the stakeholders can verify and validate the model.

Therefore, the adoption of a process-centric approach relying on a process-aware information system combining with a simulation tool (iGrafx) [20] allows the redesign of business processes in an organization. A set of process performance measures (also called key performance indicators, KPIs) can address both the general and specific functioning of the process [34]. Moreover, with a this discrete event simulator is possible not only model the process in BPMN standard language, but also add other instruments, such as monitors. The simulation is based on real data collected through data analysis about last years, as well as

monitoring one month of activities. In particular, we adopted a web-based application to collect real data from operators. Finally, scenario analysis is useful to show the impact of technological solutions on the current model, whereas some improvements are defined by the choice of appropriate performance indicators, becoming a decision support tool.

B. The e-Health technologies.

- TELEMEDICINE. A suite for telemedicine, telemonitoring, and the analysis of behavioral habits, developed by Ticuro Reply (TM). The application enables the process of guaranteeing the management and continuity of care, by using integrated medical devices with real-time data monitoring capabilities. The suite includes support for establishing secure connections between patients and professionals or amongst professionals. Being communication so important in this environment, the attention converge in making possible Televisit and Teleconsultation sessions. Therefore, health professionals are able to establish an interactive relationship with patients and their caregivers, providing them with personalized treatment paths, without being restricted by geographical limitations.
- UX PLATFORM. A systematic improvement of the process in the so-called cognitive computing framework [19] relies in the user experience. In fact, the core of the discipline "subject-oriented business process management" [16] is the behavior of the actors involved in the business operation, as well as their corresponding interactions. The results derived from the User Experience research and ethnography activities, involving patients and staff of the Hospital at Home service, informed user-centered design processes. These were adopted to design a prototype concept for a solution aimed at meeting user requirements as identified during UX research activities. The prototype application value proposition takes into consideration major pain-point and user needs, specifically regarding the management of the HaH service, and the planning of logistics required for its delivery. The value proposition is then translated into a digital platform prototype designed for doctors and nurses who play a vital role in the delivery of the home hospitalization service.

  In addition, the framework includes a digital platform prototype consisting in a software that enables medical staff to monitor the status of patients, schedule the home visit calendar, manage logistics and medical teams (the name of the platform is GoCare). The dashboard also allows the healthcare staff (during the visit and back in hospital) to update and share information helpful to manage the day-by-day visit reschedule. Moreover, the collected data allows health professionals to evaluate the workload of the HaH department and its capacity to accept new patients.

C. The re-engineering and scenario analysis.

The re-engineering of the processes consists in the creation of scenarios with process reorganization and simulation of the new configuration of the current activities to investigate changes in the As-Is model. This step includes also the

generation of a new and optimized model by considering also an individual-based perspective [31]. The simulation of the different scenarios, with the same workload (What-if analysis), allows for comparing different scenarios, also in relation to the starting As-is model. In this way, we obtain a new model of the process (To-Be) to be implemented. In detail, this phase includes solutions for restructuring the process, improving the detection and understanding of inefficiencies, bottlenecks, constraints, and risks [7, 29]. In our case study, the framework allows investigating the performance of the business process with the introduction of technological applications and e-Health technologies.

3 The Hospital at Home Service

In the "City of Health and Science" of Turin (Italy), for more than 30 years, has operated the Hospital at Home (HaH). It is a home care servicefor patients suffering of acute diseases, but who do not require equipment with high technological complexity and intensive or invasive monitoring. The hospital service has covered approximately half of the metropolitan city of Turin, one of the largest Italian city with about 850,000 inhabitants. Requests for activation of this service are made by the emergency or regular departments and by general doctors. After that, each patient is daily evaluated by the medical staff in order to establish the feasibility of hospitalization under HaH.

3.1 The As-Is model of Hospital at Home

The organisational modeling effort includes an analysis of the resources. The service available every day from 8 am to 8 pm. In the case of a night emergency, patients refer to the Regional Emergency Service, with which they have a specific memorandum of understanding. It is an integrated care service so the team is multidisciplinary and includes:

- 4 geriatric practitioners
- 2 geriatric grad students
- 14 nurses (including a nursing coordinator and a case manager)
- 1 counselor
- 1 social worker
- 4 part-time physiotherapists.

Patients are visited daily, by a practitioner or a nurse jointly or by at least one of these two professionals. For the individual patient, the therapeutic objectives are programmed during collective team meetings according to the clinical trend, helping to offer the best possible care to the patient and optimize available resources.

The service includes two main processes: the process of the acceptance of the patient and their taking in charge and the process of the tour visits of every patients in their home [6, 9].

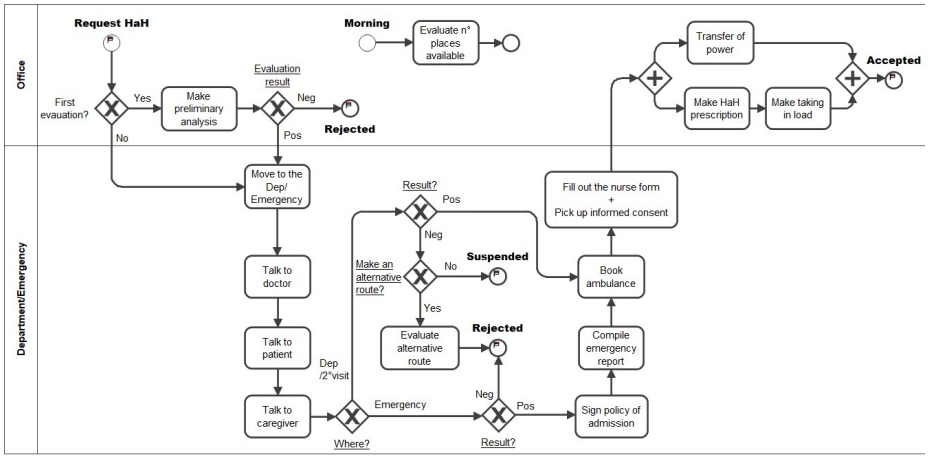

Fig. 1. Business process model of HaH service. Acceptance of requests.

The taking in charge is make by a specific nurse called Case Manager (CM), who have to evaluate all the requests and each one case according to some guideline to understand if the patient have some characteristics to allow him to take in charge to this type of hospitalization. This is a complex process including several qualitative variables, in addition to the quantitative ones. Every morning, as first thing, the Case Manager (CM) have to evaluate the available numbers of possible posts (**Evaluation n^o places available**, that correspond to the maximum numbers of patients that she could accept in that day. This is a long evaluation of on average one hour because she have to take in to account, first, the number of patient that during the day will be probably release; second, the number of staff available: for example if we are near Christmas or summer holiday sorely staff are fewer, so patients must be proportionate; and third, how long each patients, they already have in charge, been: some patients have some pathology that must imply more time then other, for example blood transfusions are longer then bandages that are longer then giving a medicine (the first type of patient occupy two slot, while the second type occupy one slot and an half and the third type occupy only one place).

This initial evaluation imply both type the variables, qualitative and quantitative, it is based on the best experience of the Case Manager made by years of experience, and it is a very important task because it determinate the future workload of all the staff involve in the service. After this task the CS can receives the requests that arrive by telephone from the emergency department or from the other hospital departments (generator **Request HaH**). The requests are made by the responsible doctors of the departments that made a first quick evaluation.

The CS has to do an initial evaluation (gateway *First evaluation?*) by phone (**Make preliminary analysis**). If there are really features not complying with

this type of hospitalization (gateway *Evaluation's result?*) the request is immediately rejected (end of the process **Rejected**). Otherwise, CM moves to the department to evaluate the patient (**Move to the Dep/Emergency**). The decision of the taking in charge the patient or not is the results of the evaluation of clinical conditions with the practitioner (**Talk to doctor**) and after a meeting with the patient, if he is conscious and capable of understanding and willing (**Talk to patient**), the family and the caregiver (**Talk to caregiver**).

If the patient will be taking in charge, he is sent home by an hospital ambulance (**Book ambulance**) and the CM collects some patient's information for the formal taking in charge , gives to the patient and to his family some information about the service including an "Informative Card" with information on the service and its organization and makes to sign and pick up informed consent to the patient, or to the caregiver if the patient is unable (**Fill out the nurse form + Pick up informed consent)**. If the patient provide by the emergency department the CM signs the policy of admission (**Sign policy of admission**) and the emergency department's doctor compiles the emergency report (**Compile emergency report**), otherwise these documents are still done upon admission to the department of origin.

The emergency department has a need to free up beds, so if the patient there is not taking in charge from the HaH service , or not immediately (gateway *Result?* and **Rejected**), he will taking in charge by the normal departments waiting for the conditions of the taking in charge (if it is possible, like some facilities for home or a caregiver or available place for the service (**Suspended**)). Other time, the CM suggests a more appropriate alternative route to the patient (gateway *Make an alternative route?*).

This service involves a lot of qualitative variable and is establish on a sort of contract of trust and collaboration among patient and hospital, so it's essential that the CM talks to the whole family nucleus to narrow contact with the patient, that must take care and divide assignments and responsibility and finally with the caregiver, that could be a relative or not. It is necessary that all these people are informed, aware and give the consent to the service, otherwise there could be severe consequences in terms of collaboration that could affect the patient's care. According to this, is not unusual that the Case Manager has a lot of tour (on average 1, 2, 3 or at most 4 in particular case for each patient) to the some patient (gateway *First evaluation* arrow 2^o visit). In all these visits is possible both taken in charge the patient, or a rejected the request or a suspended it for another visit and the trial can be repeated until the patient will be taken in charge, or the service will be refused, or the patient will die or will be discharge.

At the end of these trial with the patient the Case Manager came back to her department's office and make the administrative tasks for the patients just taken in charge (**Make taking in charge** and **Make HaH prescription** in the hospital's computer system). Furthermore, as soon as the doctors and the nurses arrive, the CM informs them about the new patients (**Transfer of power**) and the patient is definitively in the daily workload of the department of the Hospital at Home (**Accepted**). All patients receive home visits every morning but some

patients, with special conditions (poly-transfused or antibiotic therapy), may also receive an afternoon visit (see Fig. 2).

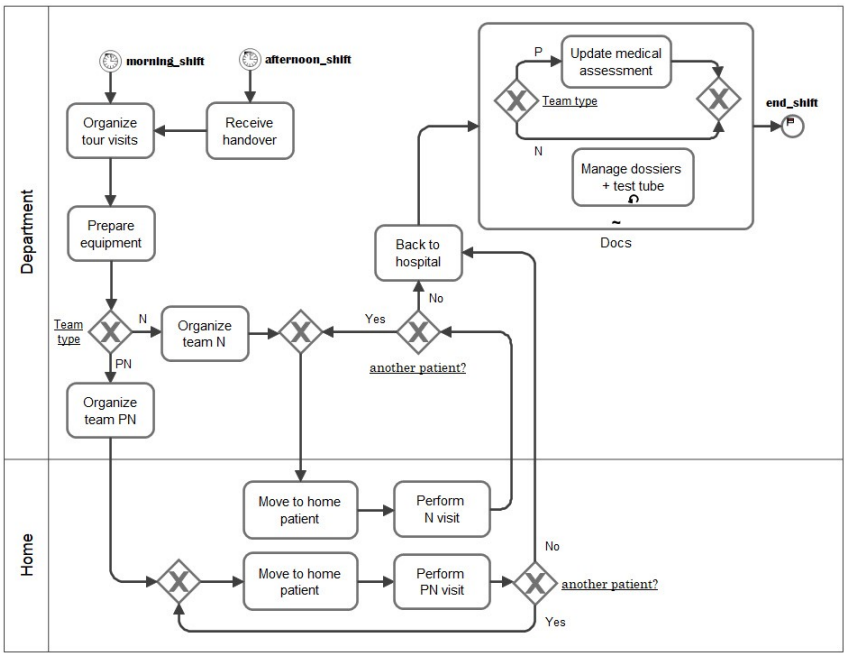

Fig. 2. Business process model of HaH service. Tour visits.

At full workload, in the morning there are 7 nurses and 4 physicians, however, there are 2 nurses and 1 physician in the afternoon involved in the shown process. This staff is then divided into teams to carry out tours and the teams are composed as follows:

- Morning, 6 team:
  - 4 team: 1 physician (or 1 grad student) + 1 nurse
  - 2 team: 1 nurse
- Afternoon, 2 team:
  - 1 team: 1 physician + 1 nurse
  - 1 team: 1 nurse

Each team visits on average 4 patients.

Firstly, in the morning, all the physicians and nurses together organize the tour visits (**Organize tour visits**). This activity consists to analyze all the patient's situations according four impact factors: medical and nursing complexity care, condition of the caregiver and geographical location of the house's patient. This allow to divide the whole amount of patients in balanced group in the sense

of time to spend in visits and time to go from one to the other; and assign to each group of patients an hospital team (gateway *Team type?* composed by one physician + one nurse **Organize team PN** or made by only one nurse **Organize team N**). After that, each nurse prepare the medical equipment for each of his patients (**Prepare equipment**). On average at 9:00-9:30 am each team take an hospital car and leaves for its ride.

Once arrived at the patient's home (**Move to home patient**), they carry out the visit: only nursing visits (**Perform N visit**) or both physician and nursing (**Perform PN visit**) depending on the ream. For the sake of simplicity, we have grouped all the activities carried out at the patient's home into a single activity called "visit". It should be noted that the tasks performed are multiple and are different, both in terms of type and time and responsibility if they are carried out by team composed by physician + nurse or by nurse alone.

Once the visit is finished, if there is another patient to visit (gateway *Another patient?*), the team heads to the second patient's house. The cycle resumes until the assigned patients are not finished; only then the team will be back to the hospital (**Back to hospital**).

The different teams return to the department at about the same time period, around 12:30-13.30 pm. Thereafter, in the hospital department both physicians and nurses have to complete some "administrative" tasks (**Update medical assessment** and **Manage dossiers + test tube**). The duty are different and specific for each of the two professional categories, including responsibility.

We have to focus the attention on the fact that each nurse and each doctor have to do the tasks and, of course, the only one computer and all the paper dossiers can be updated by one person at a time, creating a waiting queue of other staff resources.

In the meanwhile, at 12:30 pm, the afternoon shift staff arrive in the department. All those present staff make the handover: the morning staff tell the different patient's situation, one by one; and the afternoon staff receive the information (**Receive handover**) useful for organize the future work. Subsequently, they **organize tour visits**, the nurse **Prepare equipment**, they decide the team composition and start the visit tour. All the activities are the same already explain for the morning, sometime with some difference in terms of time.

3.2 As-Is model Simulations

iGrafx is the tool that we use for simulate the process. It possible to model the process in BPMN standard language, but it is also possible other added instrument, such as monitors.

The simulation is based on real data collected through a monitoring of a typical week. An application is being designed to collect much more data, for a much more long period and in real-time.

We decide to focus the attention on the visits tour process (Fig. 2) because is the more representative for the To-Be re-engineering and the more affected by the applied technologies device. On the other side, the acceptance process is full of qualitative variable which can be optimised better with other tools [10].

Therefore, in this process there are two generators of event. The first creates morning transactions, while the second generates afternoon transactions. Both the generators are based on an input excel file.

In Fig. 3 is show the first line of the excel file.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Team	N_patient	Shift	TT1	TV1	TT2	TV2	TT3	TV3	TT4	TV4	TT5	TV5	TR
2	PN	3	0	20	45	7	46	4	70	-	-	-	-	13
3	PN	4	0	21	33	24	31	14	28	13	27	-	-	15

Fig. 3. Workload specifications. An example of the spreadsheet file used to generate the simulation.

Each line of the file represents all the team's visits:

- Team: indicates the team type N, PN.
- N_patient: the number of visits of the team on that shift.
- shift: indicates the shift of the team and is a useful flag to decide the simulation flow in front of a gateway and to set some customization on task's duration.
- TT: duration of the transfer to a patient's house.
- TV: duration of a given visit in a patient's house.
- TR: duration in minutes of the travel back to the hospital department.

Note, teams can visit from 3 to 5 patients. Therefore, the first team have only three patients to visits, so only the first three travel time and visit time are complete. Equally, the second team have four patients, so the last two columns are free. This is the reasons for some empty cells.

The software is similar to Colored Petri Network so each transaction can be distinguished from the others easily by looking at transaction values like the transaction ID.

In the process, two matrices are used to store transfer and visits times from excel files (scenario attributes). A row of the matrix corresponds to a transaction; each row contains the whole tour of the team. Once created, all transactions are collected in a batch (from n to 1 transactions). Subsequently, the only transaction will disjoints at the level of teams creation.

Simulations results are show in the following tables. During the process simulation we introduce some monitor to detect the team activities. We decide to present some relevant date also useful to compare the As-Is and To-Be model.

In Table 1, each activity (subprocess Docs, Update medical assessment and Manage dossier and test tubes) includes the average cycle time employed by the activity in the week (**AvgCycle**), consisting of average working time (**AvgWork**) and average waiting time (**AvgWait**).

It is significant to note that cycle time is divided almost halfway between actual working time and waiting time in these particular activities. Table 2 show the average time of utilization (**TavgUtil**) for the whole week (cycle time

Table 1. Activity Statistics (Minutes) AS-IS

	Activity Statistics (Minutes)		
	AvgCycle	***AvgWork***	***AvgWait***
Docs	52.58	30.00	22.58
Update medical assessment	60.96	30.00	30.96
Manage dossiers and test tubes	52.58	30.00	22.58

Table 2. Resource Statistics (Hours) AS-IS

	TavgUtil
Pm_Nurse	85.76
Pm_Physician	86.22
Am_Nurse	65.94
Am_Physician	59.05

of simulation) for each type of resources: physician and nurse, both the morning shift and the afternoon shift.

In Table 3 for the complete cycle time (1 week) and for both the morning shift (**PmShift**) and the afternoon shift (**AmShift**) describe the average time of the cycle for each shift (**AvgCycle**), the standard deviation (**StdevCycle**), the average of real working time (**AvgWork**), the maximum recorded waiting time (**MaxWait**) and the average waiting time (**AvgWait**).

Similar relevant observations made in Table 1 about the waiting time is to be done on these data.

Based on the results obtained, it can be noticed that the main bottleneck is created in correspondence with the updating of the documentation at the time of the return from the visit of doctors and nurses. In fact, the nurses are engaged in the assembling and transcription of information within the paper dossiers. At the same time, doctors have only one computer available to fill out documents. In conclusion, in the morning, when there are more staff at work, in particular in correspondence of the bureaucratic activities, there is a great amount of waiting time that could be use in a better and more optimized way.

Table 3. Monitor Statistics (Minutes) AS-IS

	Monitor Statistics (Minutes)				
	AvgCycle	***StdevCycle***	***AvgWork***	***MaxWait***	***AvgWait***
AmShift	367.36	30.81	337.05	86.02	30.31
PmShift	385.92	7.38	385.90	0.02	0.02

3.3 e-Health technologies

One of the goal of the CANP project is the improvement of the process of this already innovative health service. Telemedicine/Telemonitoring (TM) may represents a potential and strong ally in the management of the patient admitted under the HaH regime and the use of communication systems in the remote management of the patient could improve treatment outcomes, increase access to care, and reduce health costs [12].

In particular we choose two different enterprise that provide us two device: the GoCare Platform by Experientia and the Ticuro Reply Platform by Santer Reply S.p.A..

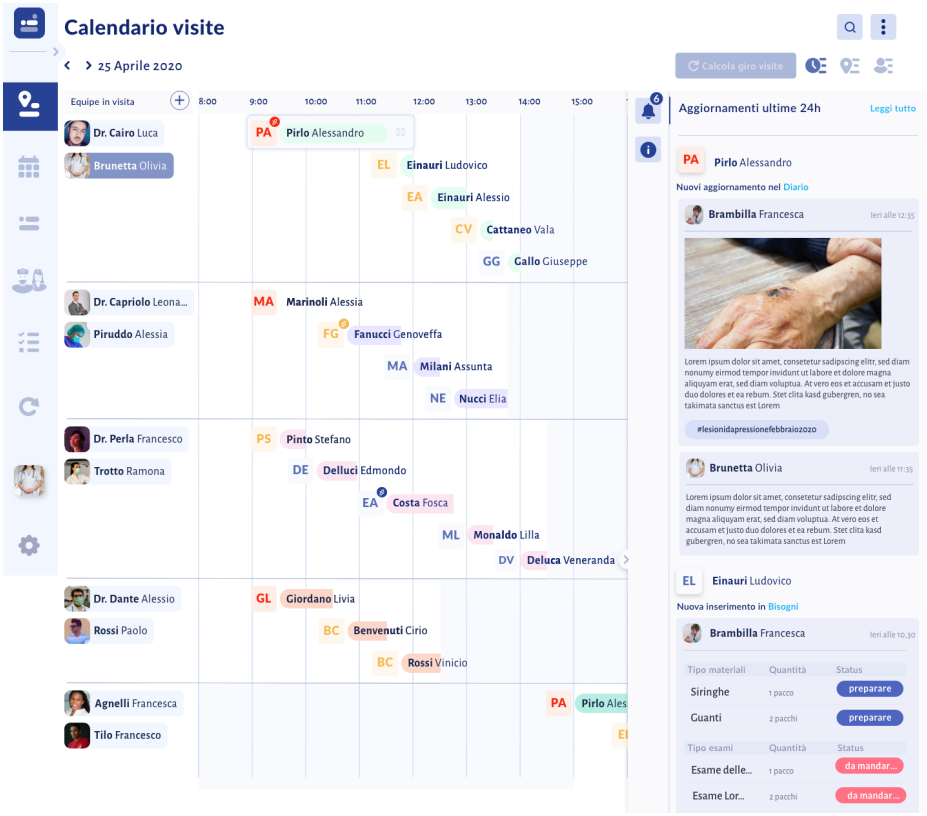

Fig. 4. Screenshot of an example page of GoCare platform. This image shows the team composition and assignment of patients to teams, distributed over the potential expected working time of the different patients based on the inserted complexity indices. (Figure has been adapted directly from [9]).

– **The GoCare Platform.** GoCare is prototype platform made by Experientia. This is a management tool that helps doctors and nurses optimize organization and logistic tasks management. The platform provides medical staff with a visual and interactive dashboard (shown in Fig. 4) to organize and manage the patient's assignment, grouping them into different visiting teams and time slots according to the impact of specific indexes. The most relevant features taken into account by the platform are the medical and nursing complexity care, the condition of the caregiver and the geographical location of the various patients. Such indexes are already evaluated manually by the medical staff to schedule and prepare the visits. As shown in Fig. 5, it is possible to see on a map how patients are distributed within the territory, and the dashboard allows manual changes. Also, the platform provides doctors and nurses the possibility of accessing the personal patient page, shown in Fig. 6. Herein it is possible to update all information regarding the patient trend (including complexity and priority indices), exams to be considered, supplies and drugs required to be prepared for the next visit, and a section to fulfill with notes, useful to analyze and evaluate patient's status. The possibility to quickly update this information, as soon as the visit is complete, allows for time savings and reduction of risk of having stray information. In conclusion, unlike the current procedure, which consists of transcribing handwritten notes on paper and then returning them to the hospital, this platform allows having all information in one single shared place accessible to all the relevant medical staff.

Fig. 5. Screenshot of an example page of GoCare platform. This image shows the geolocation of the various patients, the assignment of patients to teams, and the proposed road hogs. (Figure has been adapted directly from [9]).

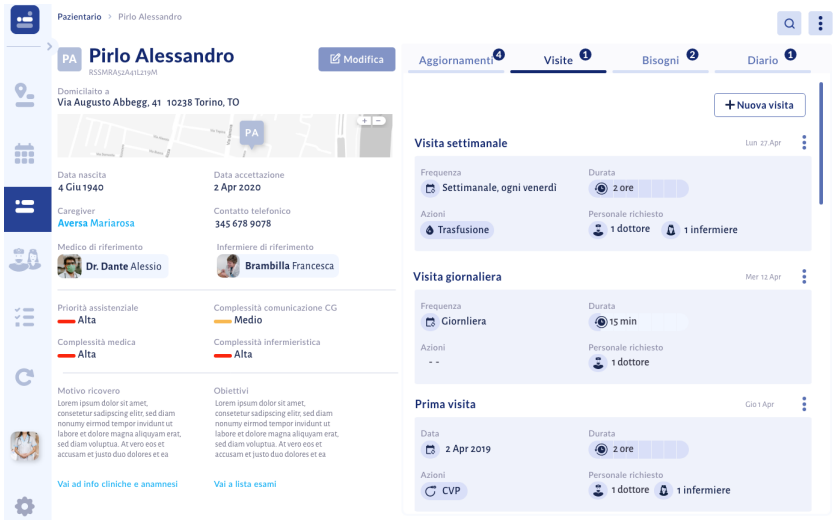

Fig. 6. Screenshot of an example page of GoCare platform. This image shows the patient's page where it is possible to consult and update the patient's actual data, his level of complexity, and information about the visit he needs. (Figure has been adapted directly from [9]).

– **The Ticuro Replay Platform.**
During the hospitalization period each group of patient-main caregiver will provided with the necessary tools of TM via Ticuro Reply platform [5]. The kit provided include sphygmomanometer, pulse oximeter, balance, thermometer, glucometer, electrocardiograph, spirometer (see attached technical datasheet). At the time of the delivery of the instruments, a specially trained nurse will give a short training to the primary caregiver and, if possible, to the patient, explaining how to use the various equipment. During pre-established time slots, the caregivers should carry out the detection of arterial pressure, peripheral arterial hemoglobin saturation, and tympanic body temperature twice a day, or once a day concerning body weight. The glucometer will be used exclusively by healthcare professionals in the case of patients requiring capillary blood sugar monitoring and the electrocardiograph will be used according to the clinical progress of the patient, always by the health care professional.
All the data recorded by the instruments will be automatically sent, in real-time, to the data collection platform Ticuro Reply and will be visible by medical and nursing staff on the same platform (as shown in Fig. 7). This allows not only timely interventions, but also preventive interventions in case values start to be outside the parameters but not yet critical to make the caregiver or the patient understand the need to make an emergency call.

[5] Ticuro Reply platform by Santer, Reply S.p.A., Turin, To, Italy

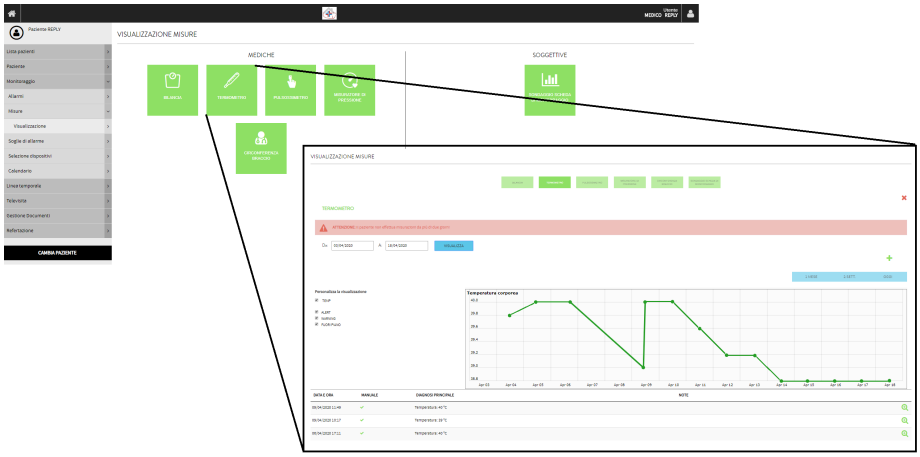

Fig. 7. Screenshot of an example personal patient's page in Ticuro Reply platform visible to hospital staff. For each patient active telemedicine devices are visible and for each device it is possible to view the data collected directly concerning the patient. (Figure has been adapted directly from [9]).

To explain the improvements, in the extended process in Fig. 8 are shown the details of the activities in the tasks **Docs** and **Perform visit** of the business process of Fig. 2. These tasks that have to be done from each nurses and each practitioners for all patients that they visit.

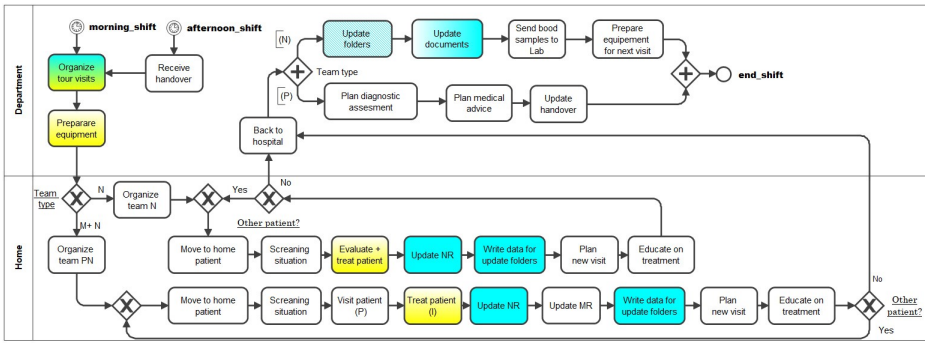

Fig. 8. Detail of the activities of the visits at home.

In particular, the process activity **Perform N visit** include:

- Screening situation
- Evaluate +treat patient
- Update Nurse Record (paper dossier)

- Write data for update folders (paper notes)
- Plan next visit
- Educate on treatment

The process activity **Perform PN visit** include the activities of the task "Perform N visit" plus:

- Visit patient
- Update Medical Record (paper dossier)

The process activity **Update medical assessment** include:

- Plan diagnostic assessment (PC)
- Plan medical advice (PC)
- Update handover (PC)

And finally, the process activity **Manage dossers + test tube** include:

- Update documents
  - Update folder (paper dossier)
  - Update patient organize (paper dossier)
  - Update patient visits (paper dossier)
  - Update delivered materials (dossier paper)
  - Update nursing records (paper dossier)
- Send blood samples to Laboratory
- Prepare equipment for next visit

There is just one PC available for all 4 physicians and, as all the paper dossier, each of them can be use obviously only by one person at a time, the others have to wait the previous to finish his duties.

Moreover, the colored activities are the one that are directed affected by the improvements (GoCare: yellow; Ticuro: blue).

The Ticuro platform could supports the organization before leaving the hospital and during the visit. During the morning organization, the medical staff has to check the measurements of the vital parameters measured with the telemedicine devices. These results may affect the choice of pharmaceuticals to bring to home patients. Currently, these vital parameters are detected by the nurse for each visit as a first step. If they are measured by caregivers several times a day, this action is not necessary during the tour visit.

On the other side, at the moment nurses have paper folders in which they take notes. Once in the office, they transcribe these notes in three different paper dossiers. This process leads to problems:

- Waste of time in reporting the same things twice.
- Increasing the chance of making mistakes.
- Increasing the waiting time in the process.

Thanks to the GoCare platform, the nurses can write directly on a personal tablet at the patient's house, saving both the transcript activity in the office and the wait to do it.

3.4 Simulations and results

Following the process in Fig. 8, we will describe which could be the differences from As-Is and To-Be processes. The next tables shown in detail the differences in terms of changing actions, Human Resources, Equipment needed, Resources involved, and the expected Time on average for each activity. The analysis considers only the colored activities of Fig.8 as they are the only ones to undergo changes.

In particular, Table 4 shows the difference made with the implementation of the Ticuro Reply platform and Table 5 shows the difference made with the implementation of GoCare platform.

Table 4. Implementation of the telemedicine of Ticuro Reply platform: comparison between the As-is and the To-be model of the Tour visits process.

	As-is	**To-be**
Activity	***Organize Tour Visits***	***Organize Tour Visits***
Action	-	Check vital signs for all patients
HR	All staff	All staff
ER	-	Tablet
Time	-	15-20 min
Activity	***Evaluate+ Treat patient***	***Evaluate+ Treat patient***
Action	Evaluate+treat +Check vital signs	Evaluate+treat -Check vital signs
HR	Nurse	Nurse
ER	Medical equipment	Medical equipment
Time	Treat+(3-15 min)	Treat+ 0 min
Activity	***Treat patient***	***Treat patient***
Action	Treat + Check vital signs	Treat - Check vital signs
HR	Nurse	Nurse
ER	Medical equipment	Medical equipment
Time	Treat+(3-15 min)	Treat+ 0 min

After the re-engineering of the process according these modification we did some simulations using the some generators of the simulations of the As-Is process.

The results in Tables 6 and 7 shown that the digitization on one side and the telemedicine on the other are really able to optimize the process.

Looking in particular at the waiting time columns on the two To-Be tables it is easy to understand the significant contribution provided by these types of improvements. In fact, they significantly reduce the workload of resources and the waiting queues once the staff returns to the department.

Table 5. Implementation of the GoCare platform: comparison between the As-is and the To-be model of the Tour visits process.

	As-is	**To-be**
Activity	***Organize Tour Visits***	***Organize Tour Visits***
Action	Organize plan visits	Organize plan visits
HR	All staff	All staff
ER	Paper dossier of: patient organize, patient visits, addresses, nursing records	Tablet
Time	90-120 min	30-50 min
Activity	***Update NR***	***Update NR***
Action	Update on paper	Update on platform
HR	Nurse	Nurse
ER	Nurse record/ folder	Tablet
Time	10min	10min
Activity	***Write data for update folder***	***Write data for update folder***
Action	Write data on notes paper	Write data on platform
HR	Nurse	Nurse
ER	Paper notes	Tablet
Time	10-20 min	10-20 min
Activity	***Update documents***	***No activity***
Action	Update paper dossier patient organize, patient visits, delivered materials, nursing records,	-
HR	All nurses	-
ER	Paper dossier 1patient organize for all, 1patient visits for all, 1delivered materials for all, 1nursing records for each,	-
Time	(30 min X 6 nurses)	0 min

Table 6. Activity Statistics (Minutes) TO-BE

	Activity Statistics (Minutes)		
	AvgCycle	***AvgWork***	***AvgWait***
Docs	21.76	17.11	4.65
Update medical assessment	39.48	30.00	9.48
Manage test tubes	21.76	4.86	16.90

Table 7. Monitor Statistics (Minutes) TO-BE

	Monitor Statistics (Minutes)				
	AvgCycle	***StdevCycle***	***AvgWork***	***MaxWait***	***AvgWait***
AmShift	330.36	21.30	324.10	29.02	6.26
PmShift	373.19	16.97	373.17	0.02	0.02

This saved time could be used to add an extra patient for each team or to extend the geographical area of the service, that currently covers about half of the city of Turin.

4 HaH and telemedicine for COVID-19 emergency

On May 2020 was lunched a project called TELEMACO with the purpose to use the HaH service and the telemedicine device to support the management of patients suspected of COVID-19 or discharged from the hospital departments with diagnosis of COVID-19. Telemedicine (TM) is emerging more and more as a virtually ideal tool in emergency situations to support patients with adequate medical care, while reducing the risk of infection between these, healthcare and the community[18].

The telemedicine device used will be Ticuro REPLY (Santer REPLY S.p.A., Milan, MI, Italy). It is a suite for telemedicine (TM), telemonitoring and the analysis of behavioral habits, able to enable the processes to guarantee the taking in charge and the continuity of care and care. The suite also includes enabling technologies for the performance of TV and teleconsulting sessions, ensuring a safe and secure connection between user and professional, or between professionals. The collected data and the possibility of a remote and continuous assistance allow health professionals to establish an interactive relationship with patients and their caregivers, providing them with personalized treatment paths.

The first results were expected after about a month from the launch of the project, but there have been changes at the level of hospital management for emergency reasons and subsequently COVID-19 cases have decreased and at Regional level it has been decided to concentrate COVID-19 patients in other hospitals. However, the emergency is now resuming and the TELEMACO project is fully ready to go. It is assumed that you will start processing the first results in less than a month.

In any case, as part of the CANP project, telemedicine was tested for MND (Motor Neuron Disease) patients suffering from COVID-19, already during the first wave, under the direction of the MND Italian National Reference Centre at the Hospital of Novara, Italy. In this case, exactly the same telemedicine devices illustrated in this article have been used. We have chosen not to go into the results obtained here because they are part of a totally different process. The results of these studies will be the result of a forthcoming publication.

5 Conclusions

This paper describes a modeling and simulation effort concerning an innovative hospital service. We show how this service is organized to ensure the taking in charge of the patient by the hospital, while the patient staying at home. On one side, this service is at the center of a big project that aims to make it even more efficient. The use of communication systems in the remote management of the patient improve treatment outcomes, increase access to care, and reduce health costs. On the other side, its innovativeness, adaptability and diffusion on the territory has revealed the service not only usable, but able to give a significant positive contribution even in a state of emergency. The adoption of simulation on the top of a business process model in BPMN has proved useful in addressing the management of the service. Scenario analysis is useful to show the impact of technological solutions on the current model. Improvements are defined by the choice of appropriate performance indicators, becoming a decision support tool. As a future work, we plan to exploit data from devices by applying process mining techniques. Considering recent developments in information technology in the field of computational computing capabilities, artificial intelligence and the spread of interconnected technological tools, the intersection between data mining and business processes modeling and analysis is promising. This is the core of the relatively new discipline Process Mining which aims to automatically discover and measure processes, by adopting automatic recordings of healthcare events (so called "event logs"). In the context of our BPM framework, we plan to exploit process mining techniques to improve both clinical and administrative processes analysis.

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