Modelling home care organisations from an operations management perspective

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1 Introduction

Home Care (HC) service is a growing sector in the area of healthcare. The WHO (2008) reported that public spending on home care accounts for more than 30 % of the resources spent on long-term care in many OECD (Organization for Economic Co-operation and Development) countries, ranging from 0.2 % of the gross domestic product in Spain to 2.75 % of the gross domestic product in Sweden. The rise of HC organisations in recent years has been accelerated by several factors, such as population ageing (from 4 % in 2010 to nearly 10 % in 2050 in OECD countries, Colombo et al. (2011)), an increase in chronic pathologies (WHO 2008), the introduction of innovative technologies, such as monitoring devices (including fall detectors or pill minders), constant pressure from governments to contain their healthcare costs [Chevreul et al. (2004), WHO (2010)] and social changes over recent decades WHO (2008).

Through the use of formal and informal caregivers and appropriate technologies, HC service aims to satisfy the health and social needs of people by providing appropriate and high-quality home-based healthcare and social services within a balanced and affordable continuum of care (WHO 2000, 2002). In the delivery of conventional care, patients move to the service point, whereas in HC delivery, practitioner activities have to be coordinated with several decentralised patient care points. Another important characteristic is that personnel and other entities involved in HC service delivery are diverse and difficult to manage in their territory. Doctors, nurses, paramedics, pharmacies, psychologists, social workers, home assistants and informal caregivers, such as familiars, are the main providers of care.

These differences induce the development of entirely different models in the planning of HC service organisation operations. New approaches are needed that will facilitate the incorporation of patient preferences in the planning of caregiver visits or the coordination of human and material resources in integrated health and social services to be delivered in a geographical area.

In this context, the lack of a framework that enables a general understanding of HC processes is a detriment to an efficient, high-quality and responsive system organisation. A recent review of Genet et al. (2011) points out that the majority of research analyses only one aspect of the HC system and does not address the entire subject. This paper aims to bridge this gap. Specifically, our work has two main contributions. First, we develop a framework (Sect. 2) with the purpose of providing a complete view of the HC service by describing the functions of the main processes. In contrast to the manufacturing sector, where companies can base their organisations on solid standard frameworks (see for example Cutting-Decelle and Michel (2003) and ISO 19439 (2006)), HC providers currently have few guidelines for the design and management of their organisations. The approach presented in this study is quite similar to the approach followed by researchers who studied operations management in a hospital setting [Harvey and Duguay (1988), Vissers et al. (2001)].

The proposed framework is formalised in an IDEF0 (Integrated Definition for Function Modelling) model to (1) describe the main therapeutic and organisational processes that are realised in HC organisations, (2) provide a formal representation

of relations that exist among activities, and (3) describe the information and physical flows, as well as decisions, that are necessary for operations management in HC organisations.

Based on the IDEF0 model, we have identified the primary details of HC operations and have classified operations management-related decisions in a HC setting (Sect. 3). The approach is similar to the approach used by Vissers et al. (2001) in a hospital setting. The use of enterprise process modelling approaches, such as IDEF0, has also been successfully observed in earlier health sector studies [Rolón et al. (2008), Hoffman (1997), Vissers (1998), Vissers and Beech (2005)] and other industries [Staccini et al. (2005), Yusuf and Smith (1996)].

Each operations management decision is described by emphasising its relevance in practice and the main challenges it faces. These decisions can be viewed as new opportunities for operations management researchers who will become engaged in this area.

The framework that we have developed does not profess to be as generic and exhaustive as existing frameworks, such as the SCOR (Supply-Chain Operations Reference) model, which is used in many industries (Li et al. (2011)). Although it is based on nine cases, the developed framework has to be deployed on a larger scale to effectively capture the differences that exist between HC organisations.

2 Descriptive model of Home Care organisations

This section presents the model developed in this study. The selection of IDEF0 for the modelling methodology is justified in Sect. 2.1. The steps followed in the development of the descriptive model are explained in Sect. 2.2. Section 2.3 describes the HC providers that were analysed in the study, and the model is presented in Sect. 2.4.

2.1 Selection of the modelling methodology

The way in which human and material resources are combined to provide coordinated and continuous HC service is complex and difficult to capture and formalise. The following requirements should be considered in the selection of the approach to be used in the modelling of HC processes:

- Different perspectives: HC processes can be analysed from the point of view of the service provider (HC organisation), the patient, or the human resources involved in the care-giving process. Hence, the modelling of the HC system can be performed from different perspectives that lead to different models, including a process (activity) model, a resource (competency) model, an information flow model, and a finance model.
- Different levels of detail: because certain processes are performed day-by-day, they can be modelled at the operational level. Other processes are more strategic, and should be modelled at an aggregate level.

- Completeness: adequate information should be provided on the most relevant HC processes, and the relationships between them should be taken into consideration.
- Clarity: HC processes that are formalised in a model should be accessible to and comprehensible for health practitioners who are generally not familiar with process modelling techniques.
- Usability: the complexity of HC processes requires compact views from which the needed information can be easily extracted.
- Different cases of use: the different contexts in which the model can be applied should be clearly stated for use by health practitioners.

The available literature based on enterprise modelling offers a set of methods to analyse and design existing or future processes within a system. Based on Shen et al. (2004), Bal (1998) and Kassem et al. (2011), several approaches can be adopted for the modelling of service organisations. The IDEF0 methodology is adopted in this work because of its ability to capture the interactions between the activities and actors. IDEF0 models include a breakdown structure in which a hierarchical set of diagrams is constructed for modelling the activities performed in the processes [Bravoco and Yadav (1985), IDEF0 (1993)]. Each activity is modelled in terms of required *inputs*, *mechanisms* used to perform the activity, *controls* governing the activity and *outputs* provided by the activity. Furthermore, IDEF0 enables the representation of all types of HC activities, including therapeutic and organisational activities, and the actors involved in the activities.

The inability of IDEF0 to represent system dynamics is not of concern because the goal is to provide a static representation of an HC organisation.

Other methods, such as ARIS (Architecture of Integrated Information Systems, 1999), allow for the representation of different points of views when analysing a system. However, the use of IDEF0 is generally preferred in situations where the experts involved in the study are not familiar with complex system representations and prefer, as was the case in this study, working with simpler representation tools.

The IDEF0 methodology has already been applied to the health domain to represent processes, such as clinical diagnosis and treatment (Cohen et al. (1995)), medication management (Bell et al. (2004)) and waiting list management (Al-Hakim (2006)). Additional references [Mykkanen et al. (2009), Rolon et al. (2008)] utilise IDEF0 models to describe healthcare systems.

2.2 Research methodology and data gathering

To construct a generic and comprehensive IDEF0 model, we selected the HC organisations to be included in the analysis by giving priority to the heterogeneity of the samples considered. This study is based on nine HC organisations that operate in different regions of France and Italy; each region has a different organisational model. Care is delivered primarily by home nurse associations or coordinated through a complex network of health organisations, while other HC structures are hospital-based. A description of these organisations and the types of delivered services is provided in Sect. 2.3.

The first step of the study was to define the boundaries of the system to be modelled and the point of view of the analysis. The developed IDEF0 model reflects the perspective of the HC service provider. All activities that relate, directly or indirectly, to the care delivery process have been considered in the model with the exception of financial processes, which are beyond the scope of this paper.

Once the core processes were defined, their supporting activities were identified. Each activity was subsequently connected to other activities through the IDEF0 formalism: the outputs of some activities serve as constraints or inputs for other activities.

A bottom-up approach, beginning with the identification of activities that were performed at the operational level, was implemented to model HC processes. Top-down and bottom-up analyses were used to check and adjust the developed model.

The analysis of the processes that occur within HC organisations has been based on a variety of different information sources:

- Official documentation, regional laws, archives, historical data, and organisational plans that were provided by the organisations in question.
- Systematic bibliographic review of the existing operations management investigations of HC processes.
- Semi-structured interviews of health professionals that were conducted at each site. The professionals involved in the study include the HC organisation management committee and the staff that are in charge of the care-giving process, logistics, quality assurance and pharmacy.

The interview phase was conducted in three steps. Following an initial meeting to explain the goals of the study and principals of the IDEF0 model, questionnaires were sent to participating HC organisations by email. The questionnaire was composed of three distinct parts: general information about the HC organisation (e.g., serviced geographical area, human resource availability and pathologies), detailed process information (e.g., existing processes, actors involved, associated information and material flows) and a description of the major problems encountered through the HC process. A glossary of terms used in the questionnaire was also included. The completed questionnaires were received 4 weeks later and verified upon receipt. If certain answers were missing or ambiguous, we contacted the participating personnel to clarify their responses. Next, we organised meetings with the participants to analyse their answers and discuss their impact on the constructed model.

One of the difficulties in presenting the IDEF0 model to HC providers is the aversion that some persons possess toward a complex network of boxes and arrows, as reported by Presley and Liles (1995). A detailed glossary, which explains the syntax used in the model, and discussions with various professionals at meetings have proven notably useful for the understanding and acceptance of the IDEF0 formalism. As detailed in the remainder of this section, empirical feedback regarding the critical aspects of certain activities or the weaknesses of their current organisations were useful in refining the IDEF0 model.

2.3 Analysis of providers and delivered services

We selected three French HC organisations, which were comprised of one public service provider and two private non for-profit providers, and six Italian HC organisations, which were comprised of one public service provider, four private non for-profit providers and one private for-profit provider. These HC organisations are located in north and central France and Italy. The French providers are operating since more time than are the Italian ones.

An analysis was developed based on a number of general attributes that were collected from the selected providers (Table 1):

- Country and geographical area covered by the service.
- Starting date of the service organisation.
- Corporate status of the company.
- Pathologies covered by their services.
- Annual number of admissions. It is related to either the first admission or readmission of a patient to the same HC organisation during the year.
- Average number of days of care per patient. This is the average length of stay for the patients that left the service during the year.
- Average number of patients in the year. This is the average number of patients that in parallel are cared for by the service organisation.
- Maximum number of patients that can be supported by the HC provider at the same time. This value has to be declared to the health governmental institutions.

HC providers can be classified by two main criteria: the pathologies suffered by their patients and patient characteristics. Regarding the pathologies in France and Italy, there are more than 20 different causes of patient admission in HC structures. Regarding patient characteristics, according to a WHO study (2008) HC providers can assist people who are chronically ill (e.g., tuberculosis, cardiovascular diseases and cancer), individuals with disabilities, people with HIV/AIDS, people disabled by accidental injuries (e.g., victims of traffic accidents), people with sensory limitations, and mentally ill individuals (e.g., depression and dementia).

The selected Italian providers are mainly dedicated to palliative care and terminal patients, i.e., providers D, E CP, F, H and I. In the analysis, provider E has been split into two divisions: palliative care and other types of healthcare. Providers E, non-CP and G, which are among the largest Italian HC organisations in terms of annual admissions and number of staff, are polyvalent. The start of activities for provider G, whose holding company succeeded in a bid for covering the needs of palliative care in a specific area of Rome, is quite recent.

2.4 An IDEF0 model for describing home care processes

2.4.1 Manage home care organisation

The first level activity in the IDEF0 model is “Manage HC Organisation” [A0], as represented by the diagram provided in Fig. 1. This activity can be broken down into five sub-activities.

Table 1 Main characteristics of the HC organisations involved in the study

Provider	Country	Region	Starting date	Corporate status	Patient Profile	Number of admissions per year	Average length of stay (days/ patient)	Average number of assisted patients (patients/day)	Capacity (patients)
A	France	Ile-De-France (Paris and 119 districts)	1957	Public service	Polyvalent and Parenteral feeding	13,726	18.44	697	820
B	France	Ile-De-France (Paris and the east of Île-de-France)	1967	Private/non for profit	Polyvalent	2,869	20	156	200
C	France	Lyon	1972	Private/non for profit	Polyvalent	969	55.54	170	230
D	Italy	Rome	1987	Private/non for profit	Oncology and terminal diseases	628	37.42	100	120
E CP	Italy	Districts of Merate, Lecco and Bellano	1992	Public service	Oncology and terminal diseases	430	62.33	109	–
E non CP	Italy	Districts of Merate, Lecco and Bellano	1992	Public service	Polyvalent	1,848	111.55	628	–
F	Italy	Turin	1983	Private/non for profit	Oncology and terminal diseases	591	36	75	87
G	Italy	Milan	1991	Private/non for profit	Polyvalent (and oncology: few cases)	1,750	130	675	800
H	Italy	Rome	2004	Private/for profit	Oncology and terminal diseases	105	25	–	30
I	Italy	Milan	1982	Private/non for profit	Oncology and terminal diseases	1,448	39.6	163	200

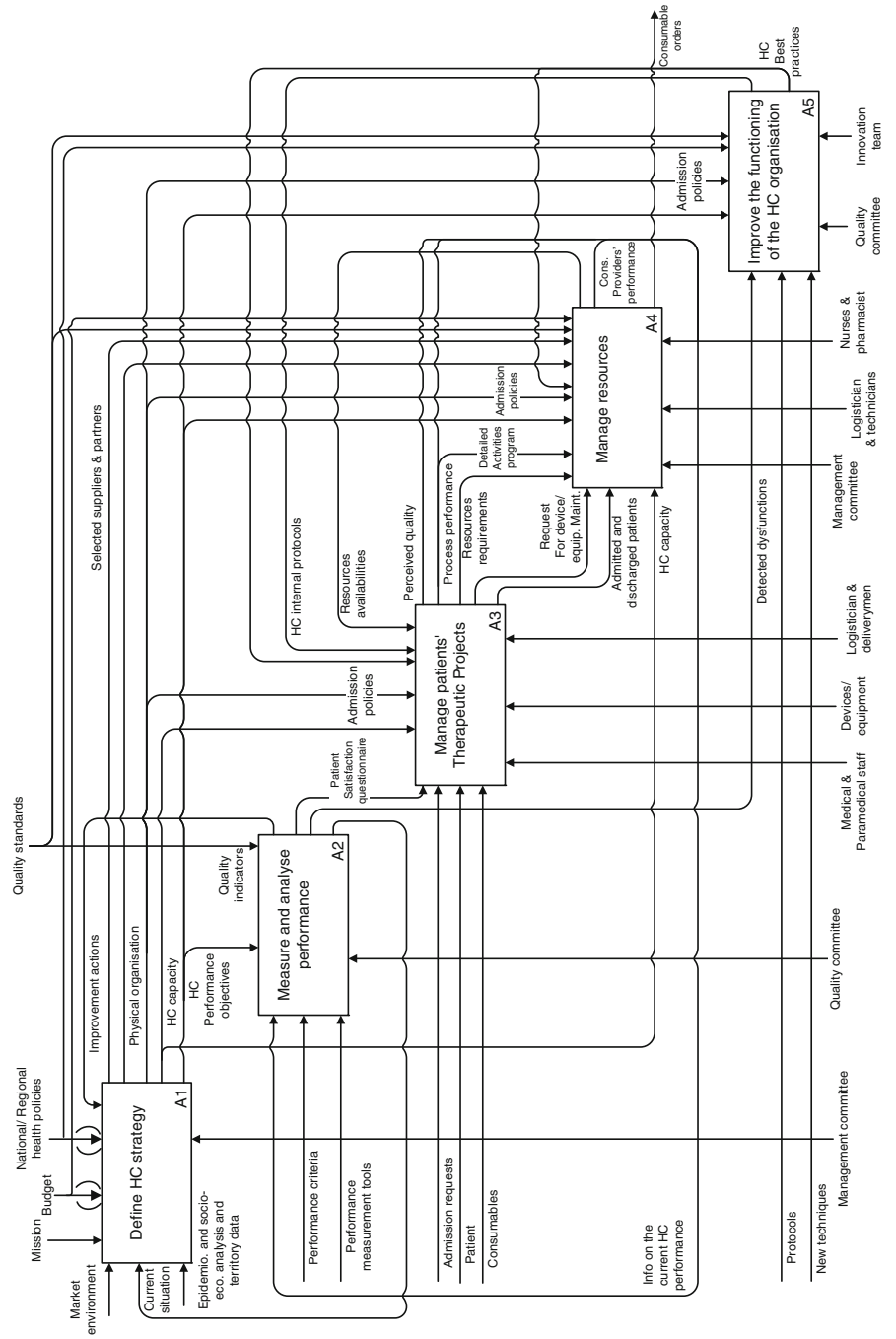

Fig. 1 IDEF0 model: A0 diagram

Define HC strategy [A1]. The main objectives, principles and plans for the HC organisation in the long term are defined according to the current market position of the provider and national and regional health policies. Government organisations generally try to cover as much of the service demand as possible (e.g., Providers A and E in Table 1). The main purpose of non-profit organisations is to provide social benefits by addressing specific pathologies that are not sufficiently covered by the public health service. Several examples include paediatric care, care for severe neurologically disabled patients, and mental diseases. Because for-profit organisations must first respond to their stakeholders, their strategy is highly competitive and closely related to the service demand.

The providers that were analysed are responsible for providing healthcare, while municipalities are responsible for providing social services. However, to deliver a customised service to the patient, the two types of care have to be integrated. This distinction between health and social services is common in many countries, such as Belgium, France, Italy, Portugal, Spain, and the United Kingdom, and causes coordination problems with service delivery. In other countries, such as Denmark, Finland and Sweden, health and social services are provided by a single organisation (World Health Organization (WHO) 2008).

The strategy of an HC organisation should also consider the available funding mechanisms in local health policies. In some regions, funding is voucher-based, i.e., the patient can select the provider that will deliver the care (providers E, G and I), while in other regions, local governments invite bids for delivering the service for a certain number of years (providers A, B, C, D, F and H). The variety of care delivery that is decided by local health policies (e.g., hospital, hospice and home) affects the presence of HC providers in a certain territory.

Strategy definition in HC has been addressed by few papers in scientific literature. Boldy and Howell (1980) presented a case study that describes the implementation of methods for geographically partitioning a set of HC human resources among several social services. Busby and Carter (2006) examined the funding issue with a data-driven decision tool that allows the administrator of a public HC organisation in Ontario to assess quantitatively the trade-offs between cost, quality (defined by the number of patient visits) and waiting time of their HC patients. Their analysis was later used to negotiate reasonable funding levels with the government. Blais et al. (2003) partitioned a territory into districts by balancing the workloads of HC nurses, which were measured as time spent with patients and time spent travelling to their homes. The homes were located in different districts of a Canadian territory.

Measure and analyse performance [A2]. This activity provides a picture of the performance of the HC organisation in relation to the defined set of strategic objectives and guidelines for improvement actions. The activity also includes the selection and implementation of adequate tools to measure the selected performance indicators. Measuring HC performance is more complex than measuring the performance of hospitals because the care is delivered in the home. Of all the tools, the patient satisfaction questionnaire seems to be of particular relevance for health practitioners. However, there is a strong need for additional indicators that can measure the quality of the delivered service and the efficiency of the organisation.

We also observed that in the current practices of HC providers, the performance of clinical aspects receives more attention than logistic and organisational matters, which clearly impacts the efficiency of care delivery. This finding confirms the study of Woodward et al. (2004), who observed that attributes that could improve the quality of care in HC organisations in Canada were not clearly defined or measured. For this reason, these researchers conducted a series of interviews with HC clients and their caregivers and concluded that to ensure the continuity of care in HC organisations, attention must be paid to the management of care and its delivery.

All of the providers that were interviewed appeared to pay particular attention to risk management issues while delivering care (e.g. during transport or in the home) or with regards to the transport of perishable and personal drugs (e.g., anti-cancer drugs). However, in this case, the providers did not adopt specific risk measures.

Manage therapeutic projects [A3]. This activity involves the operational management of patient care plans from admission to discharge. Specifically, it includes the design, planning, implementation and control of patient therapeutic projects. A therapeutic project consists of a set of planned and interrelated care activities that are performed with defined skills, within a certain budget and over a period of time, and this set is intended to achieve predefined therapeutic objectives. First, health and social conditions of potential customers are assessed to determine whether they are eligible to receive home care services and whether their care plans incorporate the specifications of required professional skills. Next, new and current care plans are compiled. Last, activity programmes subject to the availability of human and material resources are generated (Fig. 2).

All of the clinical activities are generally mandatory and governed by strict protocols, while organisational activities are typically elective, even if they are serving as supporting activities. More details on this activity are discussed in Sect. 2.4.2.

Manage resources [A4]. This activity consists of managing the human and material resources that are necessary to deliver care. HC service is labour-intensive; thus, human resource management is an important activity and does not differ notably from resource management in hospitals. With respect to materials (consumables and not consumables), except for the territorial aspect, this type of planning is not highly different from planning for hospitals and other types of services.

Resource planning and management are based on demand forecasting. Demand forecasting for HC requires forecasting the future needs in terms of the amount of the time requested for patients visits and transportations and the necessary skills and materials. Compared with demand forecasting in hospitals, demand forecasting for HC is more complex because in addition to the pathology, the social environment of the patient has an impact on individual needs. For instance, the presence or absence of familiars in the home affects the delivery of home cleaning services and the administration of certain specific therapies. Lanzarone et al. (2010) proposed a procedure to build Markovian models for the estimation of the patient-related workload and care pathway to be used in human resource planning. This topic has also been recently investigated by Garg et al. (2010a, b). However, we have observed that the demand forecast activity was missing from all of the studied HC organisations.

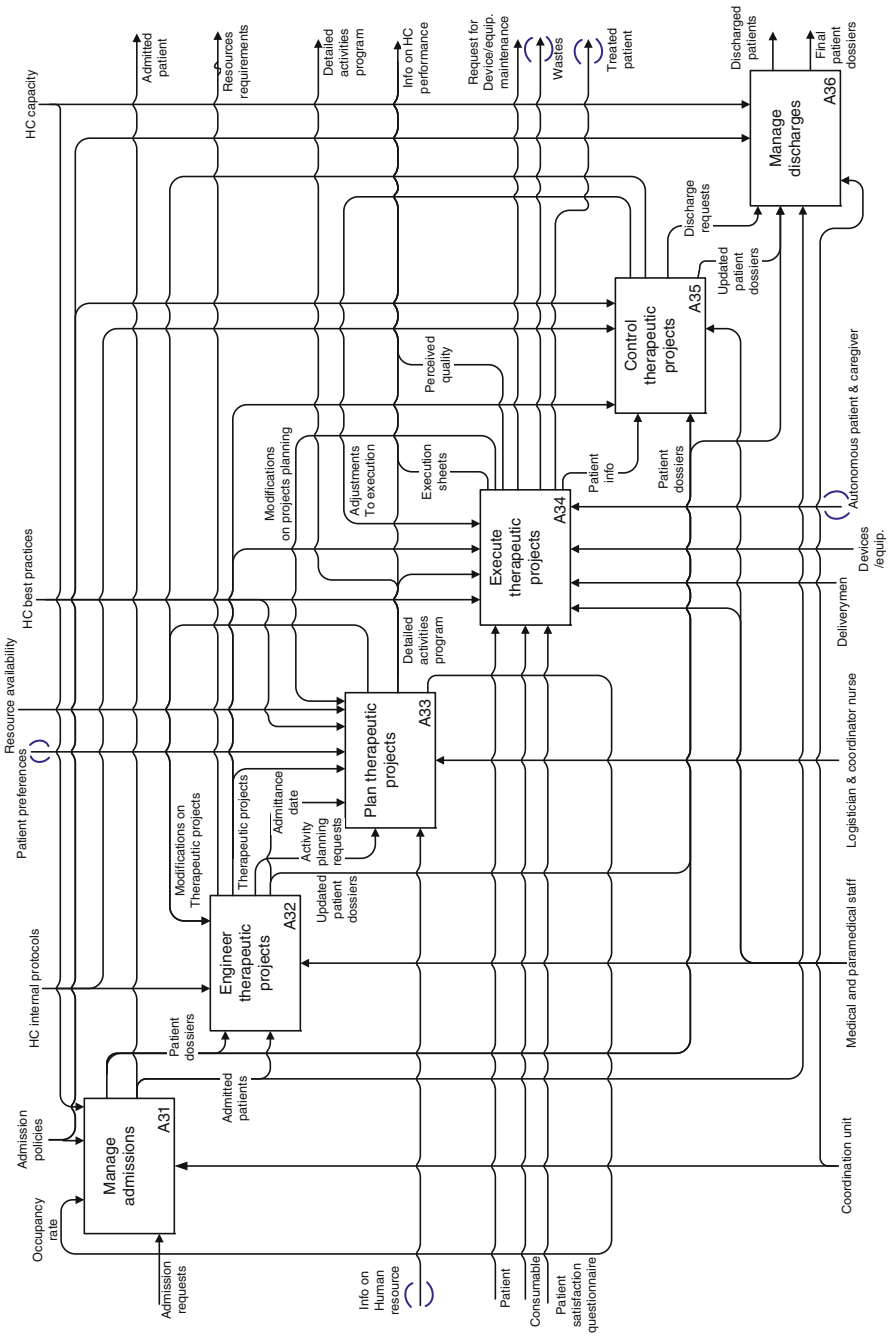

Fig. 2 IDEF0 model: A3 diagram

Improve the functioning of the HC organisation [A5]. The main objective of this activity is to improve the overall HC organisation by defining new protocols, identifying the best practices to be applied, and tracking the development of innovative technologies, such as remote monitoring systems, device performing therapies, home modifications, electronic patient records and newly developed medical treatments. In addition to the direct benefits on the patient, technology can also improve the quality of life on informal carers (e.g., familiars) who can continue their own lifestyle. Different from hospitals, the main characteristics of HC devices are their size, portability and connectivity in the home of the patient.

2.4.2 Manage therapeutic projects

This section describes in detail *activity A3, Manage Therapeutic Projects.* Figure 2 illustrates the sub-activities and the interconnections related to activity A3.

The therapeutic projects of patients can be viewed as an integration mechanism between hospitals and HC organisations to preserve the continuity of care (Chahed et al. (2006)). The therapeutic project supports the formalisation of medical and social treatments needed by patients during their stay in service. The completion of the therapeutic project depends on the fulfilment of the objectives defined for a patient.

In this paper, we adopt the term *therapeutic project* to emphasise that, similar to large engineering projects, caring for a patient is effectively a project with phases extending from design to execution and control. Other terms used by practitioners include *care plan*, *care treatment* and *individual care plan*. The latter term is used to point out that the therapy is personalised by specific patient needs. However, the therapeutic project can be viewed as broader than the care plan from the integration of planning constraints and the definition of patient admission and discharge dates. In the HC practice, the expression care plan is generally used because health professionals focus on therapeutic objectives and disregard organisational and planning issues.

Planning therapeutic projects involves the planning of human resources that must be assigned to the planned activities. Similar to a production order in a manufacturing company, a therapeutic project requires to coordinate resources to execute the activities defined in the engineered process cycle of the requested product.

The detailed activity programme is the main output of *activity A33,* "*Plan Therapeutic Projects*". This output represents a schedule of planned activities required by all of the active (i.e., new and current) therapeutic projects. The programme refers to a specific planned horizon (generally 1 week) and consists of a timetable that describes which resource will be used for which activity, as well as the location, day and time. The timetable indicates where and when to collect the drugs and other materials that are required for the care activities to be performed before visiting patients, and which professional skills will be required. The detailed activity programme plays the same role as the schedule production plan used by manufacturing companies.

Human resource planning is a key process that affects the performance of the entire service delivery. This planning activity differs from hospital resource

planning in several ways. Caregivers have to move from one patient home to another in a geographical area, whereas in hospitals, the patients are in the same building. Consequently, the relevance given to such a plan is much higher than that given to plans in hospitals. Furthermore, the integration of health and social aspects in the therapeutic project forces providers to join professionals from different organisations who have to cooperate for delivering complete care; in most cases, hospital professionals work within the same structure.

Caregivers enter the patient environment and develop, visit after visit, a personal and positive relationship with patients and their family members. We refer to this practice as the *continuity of care* policy. The advantages of this practice are that loss of information between nurses is avoided and patients perceive a better quality of care (Haggerty et al. 2003). As a consequence, the resource planner attempts to have the same caregiver deliver service to a patient. This decision has an effect on the significance of burnout syndrome of home nurses who have developed special relationships with patients (Cordes and Dougherty 1993); this problem is considered in practice by human resource planners in HC organisations.

Human resource planning takes place at different levels. In the case of full continuity of care, providers assign patients to one operator who has the proper skills to deliver the care. The sequence of visits during the day or week has to be determined for each operator. This corresponds to solving a routing problem for each operator that has to visit an assigned set of patients. The nurse-to-patient assignment problem in HC has been investigated by few researchers. Hertz and Lahrichi (2009) proposed two mixed integer programming models for assigning operators to patients. The objective is to balance operator workloads, while respecting constraints related to maximum acceptable loads and assigning exactly one nurse of each type to each patient. The possibility of assigning a patient to a nurse who does not belong to that specific district is also considered. The Tabu search technique is used to solve this problem. Lanzarone and Matta (2011) proposed an optimal assignment policy that minimises the expected average overtime cost. This policy is compared to the alternative practice of HC providers assigning the patient to the operator with the maximum expected available capacity. Ben Bachouch et al. (2008) developed a mixed integer linear programming model to minimise the total distance travelled by nurses. This model is subject to several constraints, including visit and nurse time windows, nurse meal breaks, continuity of care, nurse routes beginning and ending at the HC facility, and the maximum distance between two consecutive visits by the same nurse. Borsani et al. (2006) were interested in two planning levels, i.e., the assignment of the patients entering the system to a reference operator or team and the scheduling model, the output of which is the weekly plan for each operator. The objective of the assignment process is to ensure workload balance among operators while respecting continuity of care, qualification requirements and geographical coherence constraints. A more complete modelling framework of possible variants of the assignment problems that are encountered in HC, where authors develop a set of mathematical programming models to balance the workloads of operators within specific categories, was developed (Lanzarone et al. 2012). The models consider several peculiarities of HC services, such as the continuity of care constraint, the skills of

the operators and the districts to which patients and operators belong, under the assumption that patient demands are either deterministic or stochastic. For the stochastic demand case, the assignment problem is solved under the expected value, here-and-now, and wait-and-see approaches.

In the case of the absence of continuity of care, providers assign the activities of therapeutic projects to operators. This assigning process corresponds to solve one scheduling problem by defining the routes of all operators during a time period, typically 1 week. Similarly, for the case of partial continuity of care, a patient is assigned to a set of operators that can deliver the care. The spatial decision support system described in Begur et al. (1997) encompasses data management, scheduling, geocoding and visual interactive rerouting. For each nurse, the scheduling module that is developed provides a list of patients to be visited in an order that maximises nurse productivities. Elbanani et al. (2008) developed a model for determining routes for operators that incorporates constraints of the Vehicle Routing Problem (VRP) with the medical and continuity of care constraints. In this model, they add blood sample-related constraints as a medical constraint and consider the objective function as minimizing the total travelling cost of operators. More recently, Trautsamwieser et al. (2011) developed a model for the daily planning of HC services. The goal of the work is to secure HC services during times of natural disasters. These researchers developed the daily scheduling model as a VRP with state-dependent breaks. The objective of the model is to minimise the sum of travel times and waiting times and the dissatisfaction levels of patients and healthcare operators, which are subject to assignment constraints, working time restrictions, time windows and mandatory breaks. Rasmussen et al. (2012) provided a schedule that considers time windows for travel and visits. Nickel et al. (2012) combine meta-heuristics with methods from constraint programming to solve the scheduling problem at the week level; it is later adapted to the day level. Other works related to human resource scheduling in HC are Eveborn et al. (2006, 2009), Bertels and Fahle (2006), Akjiratikarl et al. (2007), Chahed et al. (2009), Bennett and Erera (2011), Cheng and Rich (1998).

Some organisations have adopted decentralised therapeutic project planning (providers B, D, F, G, H and I). After the assignment of the patient to the nurse, nurses create their short visit plans. Thus, the short-term planning of therapeutic projects is charged to professionals that develop their own routings. Generally, the greater the skills of professionals, the higher their autonomy; this approach is used in palliative care. Few organisations (A, C and E) are centrally organised for planning human resources that match the activities of the therapeutic project plans.

Execution of the therapeutic project (*activity A34*) concerns three types of activities: care, measure and transport activities. Measure activities can be performed in the hospital, in specialised centres during the pre-admission phase, or at home during their stay in the service, to assess whether patients are eligible for HC. This assessment involves the transportation of the patient from home to the organisation. The care activities will be performed only after the patient is admitted to the HC organisation and the home environment is set up for care. This last activity can be considered an attended service delivery (Agatz et al. 2010).

Transport activities deal with the transportation of the human and material resources necessary to provide care in the home, care units or other destinations.

Patient health status may change at any moment. As a result, the therapeutic project would require a continuous and collaborative design throughout the care giving process in addition to permanent control of the execution of programmed activities. The control of therapeutic projects (*activity A35*) involves analysing the entire service provided to patients and identifying critical situations and potential deviations from the therapeutic objectives. This control is performed at different levels of the therapeutic project lifecycle and requires potential modifications to the execution of the project or, in certain cases, the discharge of the patient. The control of HC processes is not an easy task because the patient is not under a 24-hour supervision by personnel, as in hospitals. The use of technology for this activity is expanding because early detection of patient changes may prevent unnecessary hospitalisation (World Health Organization (WHO) 2008).

The HC organisation is a node of the care network (Castelnovo et al. (2006)). Patients are generally provided by an upstream set of health organisations (e.g., hospital) and are later directed toward a set of downstream health organisations (e.g., nursing service). De Angelis (1998) developed a model that produces an optimal schedule for admitting new patients to the HC system, is subject to constraints on available resources, and considers minimum service standards, uncertainties and fixed budgets.

Patient admission is a complex process because for each of the investigated organisations, admission involves a multi-assessment team comprised of doctors, nurses and social assistants who are in charge of managing admissions (*activity A31*) and discharges (*activity A36*). This unit must assess the health and social conditions of patients to determine whether they can be admitted to a HC organisation and when they should be relieved of service. Multi-dimensional assessment of patient needs is among the most difficult tasks in HC organisation because it requires comprehension of health and social care needs, the barriers to executing daily life activities and psychological support. The lack of a generally recognised method does not allow organisations to adequately plan all of their activities when a patient is admitted.

3 Operations management-related decisions in home care organisations

Extracting operations management processes from the IDEF0 model and discussing the time horizon and frequency associated with each decision with HC practitioners enabled us to develop a GRAI model (Chahed 2008) and classify operations management-type decisions into successive plans, as shown in the hierarchy illustrated in Fig. 3. This section describes the derived classification and presents the main challenges with operations management-related decisions.

The classification described below can be considered a framework for operations management decisions in HC organisations.

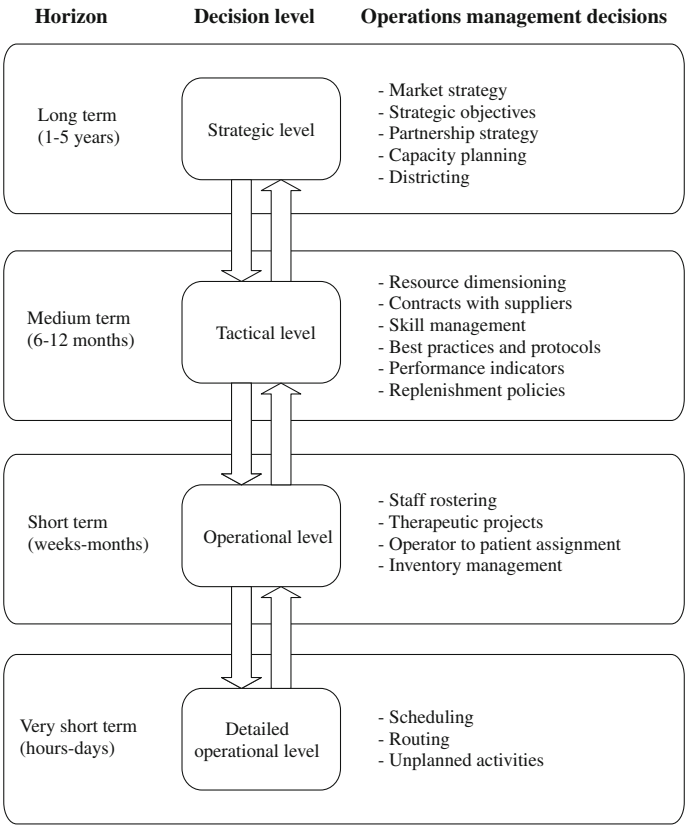

Fig. 3 Hierarchy of operations management decisions in HC organisations

3.1 Strategic decisions

Strategic decisions (horizon: 1–5 years) tend to support the long-term objectives of the HC organisation and are described in this subsection.

Defining the market strategy: the HC organisation defines the types of delivered services, the profile of the patient and the covered geographical area. This decision is closely related to the funding mechanism and the mission of the service organisation. Because there is not a general HC model recognised by governments and professionals, this sector is still undergoing relevant changes compared with other healthcare systems. Thus, defining a long-term strategy in this unstable environment is a challenging task. The uncertainty of the environment is the major issue to consider in the decision making process.

Identifying the strategic objectives: the long-term objectives have to be clearly defined to steer other decision-making activities at lower levels. This strategic decision is common to most service organisations; as a result, we do not provide further detail.

Partnership selection: identifying the partners with which the organisation can gain long-term advantages. For instance, hospitals partner for planning admissions, care suppliers partner for synergies with other HC providers and suppliers of medical devices and consumables. These examples require further study to better understand the advantages of the partnerships and the possible modes in which the partnership enrolled.

The partnership with hospitals could provide an increase in potential customers and patient information prior to their arrival. This information could be used by the organisation to plan in advance activities and optimise its use of resources. However, the value of this information and the coordination mechanisms between hospitals and HC organisations are unknown. For example, in the context of HC, push coordination mechanisms that are used in manufacturing could be transferred for this purpose.

Several providers could agree to a network partnership to cover the service demand in a territory. This approach is similar to networks of small manufacturing enterprises that share products and production capacity. Simple examples of such partnerships in the HC sector already exist, due to the small dimensions of most HC companies. In this case, several issues related to cooperation in HC remain to be investigated. Several examples are to quantify the value of the cooperation, define the conditions for a profitable cooperation between two organisations, and define the possible types of cooperation.

Capacity planning: defining the service capacity in terms of the aggregate number of professionals for type of care. This decision can be modelled as a capacity planning problem in which the decision variable is the number of resources that the organisation should use to match the market demand. Because the resources are heterogeneous, the problem is multidimensional and considers nurses, physiotherapists, home assistants and clinical devices that are specific to the pathology addressed. Resources are limited in time availability and are not interchangeable.

If a customer is not serviced, the penalties to consider are not clear and are dependent on the type of disservice (e.g., a visit or the inability to admit a patient), the mission of the HC organisation, region, funding mechanism and patient pathology. Research investigations that study the relationship between possible objective functions with specific pathologies in different scenarios could be useful in defining the capacity planning problem.

Adequate capacity is essential for addressing the demand for services in a territory. Service demand is uncertain and can be estimated at this level by an epidemiological analysis of the territory. This analysis is infrequent and is focused only on limited specific pathologies when available. The estimation of care demand appears to be a significant challenge in defining the aggregated service capacity. The demand estimate could also prove useful for a variety of other decisions, including patient admission and planning of resources and materials. However, HC providers have no tools for this estimation.

Districting: grouping small geographic areas into larger clusters called districts such that they are defined as "good" according to relevant criteria. The criteria can be related to the demand for service, demography, and geographical characteristics. Districts are used to simplify the resource assignment problem because patients are

first assigned to a district and later are assigned to a specific operator that is available in the same district. Districting allows HC organisations to maintain low travel resource costs. Generally, districts have local operational centres and are managed independently from one another. However, an interdependence among districts can occur when they do not cover a sufficient geographical area.

While the districting problem is not present in hospital decision making, it can pose difficulties in determining the number of districts in which to divide a geographical area and the composition of each district. The problem also stems from multiple criteria, some of which are difficult to quantify. The criteria combinations in a mathematical model are complex and require specific solutions. As in the capacity planning problem, the demand for service is uncertain, which creates unbalance among the districts in the short term.

Research so far has mainly addressed political districting, sales districting and police districting; few studies have analysed the HC sector. Rather than confront the districting problem with a structured approach, HC providers partition territories by their geography.

3.2 Tactical decisions

Tactical decisions (horizon: 6–12 months) deal with implementation of strategic decisions.

Resource dimensioning: the human and material resources that are used in each district. This decision pertains mainly to human resources, i.e., the number of professionals working in the districts. The organisation can also use external professionals for delivering care to serviced patients. In this case, external operators can be paid on a delivered visit basis or a managed case basis.

Resource dimensioning can be formulated as a multiresource allocation problem when attempting to satisfy an uncertain service demand from each district. The main challenge is related to the estimation of the demand for service. Another difficulty pertains to the complexity of the problem that may increase if districts are managed in a coordinated manner.

HC providers generally lack a sufficient operations management background to solve this problem and are often faced with unbalanced resources among the districts. In practice, these problems are solved by redistributing resources among districts, which increases transportation times and costs.

Defining contracts with partners: defining specific agreements with suppliers for the purchase of consumables and renting medical equipment. Relationships with hospitals can be governed by setting up an HC organisational unit within hospitals or by establishing a procedure that guarantees care coverage and continuity of therapy between demission from the hospital and admission into HC service.

Skill management: defining the paths for improving the skills of professionals that work in the organisation. These learning paths can be made horizontal by enhancing the pathology skills of specialised nurses or the paths can be made vertical by increasing their specialisation in a specific pathology. Compared with industrial companies, skill management is facilitated by an annual course

requirement for health professionals that is recognised by health authorities. This is very similar to hospital environments.

Defining best practices and protocols: defining the procedures for each activity. The definition of protocols, as they occur in hospitals, is based on clinical aspects. The best practices are related to organisational activities.

Defining performance indicators: selection of the performance indicators and their related measurement tools. This study has confirmed previous research findings about the lack of an adequate set of indicators for measuring the service quality of HC organisations. The main challenge is creating a general and recognised (by care providers) definition of the dimensions of the assessment. Because HC services are related to health and social care, psychological aspects are also involved and logistical activities are executed daily. Furthermore, the managed cases are sufficiently heterogeneous that it becomes difficult to propose performance metrics that are valid for the whole organisation.

Measuring the quality of healthcare services is difficult in any setting but is particularly complex when care is delivered in the homes of patients. The loss of quality in home care includes (but is not limited to) the following: physical injury that may be intentional or accidental, operator tardiness, failure to spend the specified amount of time with the patient, improper performance while providing care, disrespect for the privacy of the patient, intimidation, theft, and financial exploitation. If the perspective of operators or the management committee of the HC organisation is adopted, quality indicators will change and lead to different quality frameworks.

The quality of service provided by HC organisations is an open-ended issue that has not been well-defined in studies. Although researchers have developed a variety of approaches for determining the quality of HC services, an adequate performance evaluation method has not yet been developed.

Material replenishment policies: definition of consumable inventory policies. This decision is purely logistical and can be supported by several tools already in use by hospitals (e.g., hospital pharmacies) and industrial organisations. Contrary to hospitals, in which the replenishment of life-saving drugs is imperative, material replenishment in HC is not critical in HC service organisations because acute treatments are executed in more specialised structures.

3.3 Operational decisions

Operational level decisions (horizon: week-months) concern the management of flows and the coordination of activities. These decisions include the following:

Staff rostering: allocation of operators to shifts that in certain cases may cover a service provided for 24 h a day, 7 days a week. This decision is similar to decisions made in hospitals and is not addressed by this study.

Therapeutic project planning: management of admissions and discharges, re-direction of patients to other healthcare delivery structures, and determination of the type of care to deliver. This planning is executed for each assisted patient and will affect the resource planning activity that organises the resources to deliver the care. The necessity of customising care programmes makes each therapeutic plan

specific. Furthermore, because patient treatment is realised at home, the social and psychological conditions of patients have to be considered (Chahed et al. (2006)).

A frequent decision made by HC providers is the admission (or not) of a patient into the service. This decision is related to the available service capacity and the quantity of service that the patient will require. Both are uncertain because the available service capacity is dependent on the unreliability of resources and the randomness of patient requests. The available service capacity can be estimated based on the current schedule that is not detailed at the day level in many HC organisations.

The improper acceptance of a highly intensive patient can overwhelm certain key critical resources, thereby delaying the admission of other patients who will have to wait longer to be accepted into the service. The problem of estimating the demand for service relating to a specific patient remains unsolved. Patient status may change rapidly, and this uncertainty has to be considered in the patient admission problem.

The patient admission problem is part of the more general problem of deciding the care pathway for a specific patient, i.e., how to manage and dispatch the patient through the health network (e.g., hospital, HC, specialist, hospice, and family doctor). For instance, given the clinical history of a patient with a specific pathology and the occurrence of an event such as the inability of the patient to cook at home, which structure can provide the proper care most efficiently ? In certain countries, governments and insurance companies that pay for the care of their customers are interested in such problems.

There is no model available to HC providers that supports therapeutic project planning from the operations management point of view. Such models would greatly improve the performance of HC providers by allowing them to manage assisted patients optimally.

Operator assignment: the assignment of patients to nurses when continuity of care is pursued by the organisation. As explained in the previous section, this decision is notably specific to home care, due to the relationships between the operator and the patient considering the home context and familiars of the patient. Specifically, the operator assignment problem corresponds to finding the operator that will deliver a certain type of care for each patient. Assignment of nurses to patients is the most common assignment problem in HC.

The assignment has to consider the workload balance between operators, travel time, availability of operators and higher compensation for overtime. Patient requests and the operator workload that is related to a set of assigned patients are random.

Assignment is also related to districts. To simplify the assignment problem, HC providers tend to have a high number of (small) districts, which reduces optimality because of the reduced number of the possible assignments. There is a lack of research on the relationship between districting and assignment problems.

In the practice of HC providers, nurse assignments also consider the stress of operators. The assignments exclude stressed operators who deliver care in critical conditions (e.g., to a terminal patient or during the night). Such practice aims to prevent operators from burn-out syndrome. Including the quantitative stress of operators in the assignment problem would prove challenging.

Inventory management: replenishment of materials according to the policies defined at the tactical level. The manner in which materials are managed does not differ from the way that they are managed in hospitals.

3.4 Detailed operational decisions

Detailed operational level decisions (horizon: hours-days) concern the planning, coordination and control of day-to-day activities. These decisions include the following:

Scheduling: the assignment of resources for activities (transportation, visits, material handling, etc.) with time specifications. As far as visits are concerned, scheduling is not executed in the case of continuity of care because operators have already been assigned to patients during admission.

Scheduling in HC is made complex by its main characteristics: the delivery of the service in the homes of patients and the great uncertainty inherent to the process. In addition, several other modelling issues need to be considered: the effect of operator skill on activity duration, the need for multiple operators for a specific visit, the impact of patient preferences on visitation schedules and precedence constraints between activities. As far as the objective function to pursue, there are several criteria such as the minimisation of travelling time, minimisation of overtime cost, minimization of number of uncovered visits and maximisation of patient satisfaction.

Solving a complete scheduling problem in HC is quite challenging because a HC organisation can serve hundreds of patients within a territory. Approximate solutions are necessary to improve the efficiency of scheduling plans in HC. Solution techniques taken from the industrial sector can be applied to this problem. Nevertheless, these techniques must be modified to afford greater variability related to patient demand and the modelling of demand satisfaction as a constraint to satisfy.

Routing: the sequence of activities that each operator has to execute during a period. Routing corresponds to the travel required by each operator to visit a set of assigned patients. As with scheduling, time windows and the limited availability of resources make the problem more complex.

Management of unplanned activities: control of disruptions, redefinition of routes, and changes to the schedule. Because patients are not hospitalised inside the same care unit, they need to be treated individually. The responsiveness to patient requests is lower than the response provided in hospitals, where patients are grouped within care units. Decision support systems that enable HC professionals to assist within a territory have not yet been developed. These systems could utilise updated communication technologies to apply real-time information regarding operator routes and execution of activities in redefining daily activity plans.

4 Conclusions

HC is a relatively new health sector compared with hospitals. The current fragmented HC market consists primarily of small-to-medium size providers that operate with few guidelines for best practices. These providers would benefit from

improved satisfaction of patients while controlling their investment and operating costs. Hence, before the question "How can we make operations management in HC organisations more efficient ?" can be answered, we need to know what operations management in HC organisations entails and what are the most challenging issues from an operations management perspective. These questions provided the motivation for this paper.

The first contribution to this paper is a descriptive model of HC processes. The IDEF0 model that was developed in this work accomplishes the following: identifies the main therapeutic and organisational processes realised in HC organisations, gives a formal representation of the relationships that exist between activities, and identifies the information and physical flows and the decisions necessary to manage operations in HC organisations. Specificities of HC organisations have also been emphasised in relation to other providers of goods and services. To the best of our knowledge, such a contribution has not been presented in the emerging research of operations management in home care settings.

The second contribution to the paper is the representation of decisions related to the domain of operations management in HC organisations and associated information. Our experience with HC providers indicates that they are increasingly convinced of the need for validation of organisational and logistic activities and their coordination with medical processes.

This study is based on nine case studies, which enabled us to understand the variability that may exist between different organisations in terms of existing operations and the way they are managed. In this context, the feedback we gathered from HC professionals was extremely important. The feedback enabled us to revise our initial IDEF0 model and to highlight the importance of some factors that were not considered at the beginning of our study.

Most of the HC professionals that were involved in the study appreciated the completeness of the IDEF0 model that we developed and its ability to represent the interactions among activities. They reported the lack of comprehensive mapping of the processes in which they are involved on a daily basis. HC professionals added that process mapping could serve as a basis for the quality of certification or accreditation programmes that HC services have to implement.

From an academic point of view, this paper can be viewed as a building block for researchers who would like to understand better the relatively new area of HC services. HC is a field in which operations management principles require adaptations to the specificities of services provided at home.

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