Models of Child Health Appraised

(A Study of Primary Healthcare in 30 European countries)

Work Package 1: Identification of models of children's primary care: **Integrating a conceptual representation of business model with UML**

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Integrating a conceptual representation of business model with UML

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1 Introduction

This deliverable describes the methodology that is going to be used to compare primary care provision for children in Europe, thus contributing to achieve the MOCHA objectives of identifying optimal models of child care.

The privileged point of view of the comparison is the analysis of the business model defined as "an abstract representation of an organization, be it conceptual, textual, and/or graphical, describing a set of strategic choices and alternatives to support an organization to create, deliver and capture different forms of value according to its purpose, goals, plans, processes, resources and rules". (Al-Debei et al., 2008; Eriksson & Magnus, 2000). Under this perspective the organization of a health system, with its strategic view and values attributed to health care provision, is described focusing on the business process, that is "a collection of activities designed to produce a specific output for a particular customer or market" (REQB, 2015), where the outputs can be health outcomes, but also successful coordination or efficient use of resources for a child care with specific health needs.

UML (Unified Modelling Language) is a suitable formal language that provides a set of tools that document the analysis of an information system and capture its requirements. Even if it has been developed and used to design software applications (Rumbaugh et al., 2005), it has been applied to model business process (Engels et al., 2005; Eriksson & Penker, 2000; Russell et al., 2006; Dijkman et al., 2002) also in complex systems such as health care (Vasilakis et al., 2008; Kumarapeli et al., 2007; Knape et al., 2003; Mauro et al., 2010).

However, to achieve a robust comparison of health care delivery in 30 EU countries, it was necessary to add to the UML description two preliminary steps that set a common framework facilitating the selection of similar process description. This additional steps are: a) the construction of a rich picture that identifies the main components of child-centred system of care, and b) the maps of building blocks that is used to conceptually isolate and single out meaningful parts of the child health care pathways so to facilitate the comparison between national health systems.

This methodology has the advantage of making comparison of child health care systems on the basis of homogenous, well-defined parts of the process of child care. Moreover, it is flexible enough to allow analysing parts of the process selected on the basis of the case studies identified by the MOCHA partners for the investigation and appraisal of national systems of health. Finally, this methodology is also suited to consider the interaction between primary and secondary care and/or complex care as well as the analysis of interfaces with social services within national health care systems.

The deliverable is structured as follows. It first provides the description of the proposed methodology also detailing the relevant literature of each model applied as well as its use in the MOCHA perspective. The third chapter reports the application of the proposed methodology using asthma disease management as an example. In the appendix the notation for UML uses case and activity diagram are reported.

2 Methods

The appraisal of models of care carried out in MOCHA project are mainly based on the analysis of significant case studies collected in other tasks of the project, that are described in the responses of the

country agents. Considering that generally UML provides a standardized modelling language for the description of processes specifically devoted to software engineering, to produce a consistent and scientifically sound description addressing the MOCHA purposes and in particular the achievement of task 5 of WP1, the first challenge of our work was to develop a conceptual model to be used as the basis of process description. Therefore, given the objectives of the MOCHA project, we need to add a preliminary phase that sets the criteria of comparable process descriptions. The methodology based on the combination of the conceptual model and the UML diagrams is described in Table 1 highlighting the main steps to be followed to identify homogeneous part of the process of child care that can facilitate the comparison between national health systems.

Table 1: Main steps of the proposed methodology highlighting, the main aim of each step, the method used to achieve it as well as its input information required and the results obtained.

		#	Aim	Method	Input	Result of the step
Model level of refinement: Low → High	Conceptual model	1	Identify the main components that influence the child care from the MOCHA perspective	Rich picture	MOCHA objectives Vision of child care	Determinants of care, set of macro-processes relevant for the process-oriented analysis, main actors and organizations involved
		2	Identify the macro-processes and macro-activities that describe the child care	Map of building blocks	Rich picture	For each macro-process, identification of the generic workflow and of the linked macro-activities, i.e. building blocks.
	UML model	3	Identify the activities, the actors involved and their relationships of a specific health issue	Use case diagrams	Macro-processes Guidelines	For each macro-activity, each use case diagram identifies possible actors and roles involved. They are based on relevant guidelines but not dependent on a specific national health system.
		4	Identify similarities and differences between countries in terms of: • Activities performed • Actors involved • Where it is executed • Timeline	Activity diagrams	Use cases Case studies National norms and regulations	For each use case, a set of activity diagrams is defined grouping countries with similar process performance. They identify the sequence of activities and messages exchanged, the actors involved and their relationships and interactions.

The proposed conceptual model is based on two main views: the first one, at a high level of abstraction, is called *rich picture* and is developed to identify the main components that influence the child care. To achieve our specific task the *rich picture* focuses on the business process description identifying the macro-processes that are relevant for the analysis.

The second point of view, called *map of building blocks* is a refinement of the rich picture that specifies the macro-processes describing its generic workflows and related macro-activities. This is used to single out/isolate homogeneous, comparable parts of the process (the so called building block) that have to be taken into account when analysing the different national care provision.

This conceptual point of view is the starting point to apply and develop the UML models that are relevant for the process description. In particular, *UML use case diagram* describes a single, previously identified building block identifying the actors interacting in the execution of the activities performed

in a given use case based on the management of a specific health issue. The development of the use case diagram is based on relevant guidelines but is not dependent on a specific country health system.

Finally, once the actors and activities of a specific building block have been identified, *UML activity diagrams* are used to group similar country-based performance of the process, so that their descriptions can help identifying similarities and/or differences in the provision of child care, specifically in terms of: activities performed, actors involved, where it is executed and timeline.

This methodology has been presented and discussed in the two MOCHA workshops – the quality workshop held in Rome and the Modelling workshop held in Surrey – as well as in the WP1 and WP2 Meeting in Dublin. Inputs from MOCHA team members have been taken into account to enrich the content of the rich picture as well as the maps of building blocks.

Each business model applied in the proposed methodology is further described in the following paragraphs.

2.1 Development of a rich picture

The concept of rich picture generates from the "Soft System' methodology" (SSM) developed in the '80s by Peter Checkland and colleagues (Checkland, 1981; Checkland, 1985; Checkland and Scholes, 1990) who proposed a methodology of system engineering able to capture a holistic, real-world complex view of a given situation that can be a program, issue, initiative a specific setting. The building of a rich picture is one of the first steps of SSM methodology and consists of a "compilation of drawings, pictures, symbols and text that represent a particular situation or issue from the viewpoint(s) of the person or people who drew them" (OpenLearn, 2012). This conceptual model has also been adopted by different teams in the health care context (McGeorge et al., 2011; Darzentas & Spyrou, 1993; Mansour et al., 2005; Checkland, 2000).

Even if there are no fixed rules to be applied and syntax to be agreed on, a rich picture is generally developed identifying primary stakeholders, their interrelationships, their concerns as well as structures and processes that outline the context at a high-grained level of description (Monk & Steve, 1998).

In our vision, the rich picture is centred on child care and considers the main processes along with the different components influencing child health. It helps us setting the boundaries of the health care system we are going to analyse and compare across European countries. The identified processes are further detailed in the map of building block.

2.2 Maps of building blocks

The concept of building block has been used in various approaches, such as the WHO[1]. Coherently with the purposes of our task the reference point of this concept comes from the research and development area of Business Process Modelling. In this area, a building block is identified to understand users' needs in complex contexts where an information system and/or an organization is going to be embedded. It is generally used to capture software high-level functionalities from an implementation (Suitt, 2014; Coad, 1992; Dhara et al., 2015) and an architectural point of view (TOGAF, 2011; McLeod, 2011; Müller, 2003), independent of technology and implementation choices. A common feature of building blocks is that they are easily re-usable and replaceable in the different part of software

[1] The concept of building blocks has been also adopted by the WHO within a framework that describes health systems in terms of six core components or "building blocks": service delivery, health workforce, health information systems, access to essential medicine, financing and leadership/governance (WHO, 2010).

development. This flexibility makes building blocks also suitable for the high-level description of business process fulfilling the purposes of our task.

In our approach a *map of building blocks* is a first refinement of the rich picture focusing on the identification of the main processes to be analysed in the provision of child care. Each map is a still high-level conceptual description of our vision of child care that represents one of the main health care pathways a child may experience throughout his/her psychophysical development. A map consists of a core process that represents the main workflow composed by a sequence of building blocks executed in parallel or in series to accomplish a well-defined objective. Decision points are also included in the workflow to determine alternative as well as parallel paths within a process flow depending on the condition applied. Generally, the condition depends on the result of a specific building block, on the health status of the child and/or on the determinants of health. Additional building blocks (that we call linked building blocks) are included in the map representing macro-activities that can be executed in certain circumstances and anytime within the main process. They may also represent macro-processes that are executed in other settings of child care, for instance performed by specific health care services and/or stakeholders. In this way we can represent interacting macro-process that for instance can describe interfaces between primary and secondary care or primary and social care services.

In our vision, a building block acts as a meaningful and self-consistent component of a health care process. Every building block consists of:

- an entry point: an event that triggers the process, e.g. child experienced an episode of care;
- a set of activities: that describes the interaction between different actors (carers, care recipient, family other third parties) eventually including a technological support to pursue an aim and/or address a concern;
- an exit point: that shows that the process is concluded, e.g. the diagnosis is confirmed.

The intrinsic homogeneity of the structure of the building block makes it able to be "isolated" from the specific process and, when possible, re-used in similar moments in different scenarios (for instance related to different pathologies).

2.3 UML model

The UML is a general-purpose, developmental, modelling language in the field of software engineering, that is intended to provide a standard way to visualize the design of a system (Rumbaugh et al., 2005). It combines techniques from data modelling, business modelling, object modelling and component modelling and can be used across different implementation technologies throughout the software development life-cycle both from a technological and methodological point of view (Sommerville, 2008). UML is based on a semi-graphical and a semi-formal notation with a precise semantics. The different aspects of the system under analysis are described on the basis of different diagrams (note that, at the moment, UML version 2.5 has 14 type of diagrams) that describe the structure (static description) and the behaviour (dynamic comportment) of the system. Diagrams to be developed are selected taking into account the viewpoint of the relevant stakeholder in describing and evaluating the functioning of complex systems. In particular, UML provides the following views and for each view it indicates the relevant diagrams to be developed (fig. 1) (Kruchten, 1995; Breu et al., 1998):

1. Logical view: refers to the functionalities provided by the system to end-users;
2. Development view: illustrates a system from a programmer's perspective and is concerned with software management. This view is also known as the implementation view;
3. Process view: deals with the dynamic aspects of the system; explains the system processes and how they communicate, and focuses on the runtime behaviour of the system;

4. Physical view: depicts the system from a system engineer's point of view. It is concerned with the topology of software components on the physical layer, as well as the physical connections between these components;
5. Scenario (use case) view: the description of an architecture is illustrated using a small set of use cases, or scenarios that describe sequences of interactions between objects and subjects, and between processes.

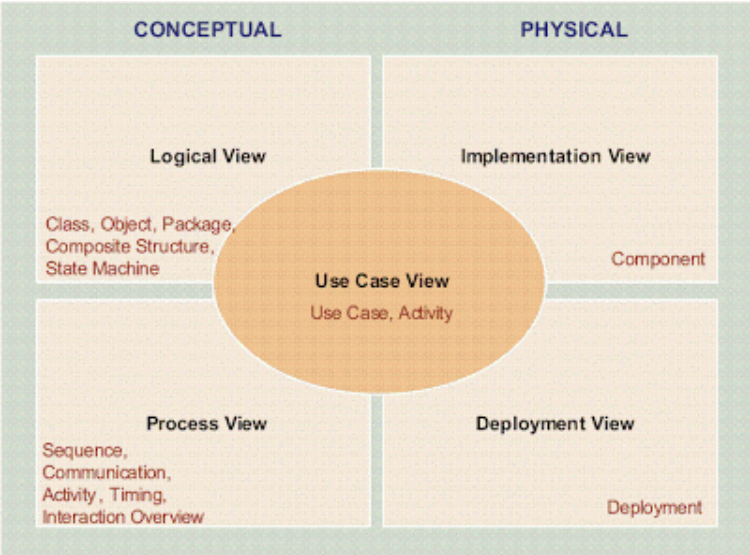


Figure 1: The UML different views highlighting the conceptual and physical perspective as well as the UML diagrams adopted to describe each view (from http://everspring79.blogspot.it/2008/09/uml-41-view-materials.html).

For the purposes of our task, the scenario (use case) view is a suitable perspective to describe the business process modelling, even if in software engineering it is mainly used to identify architectural elements and to illustrate and validate the architecture design. Therefore, the application of the use case and the activity diagrams are appropriate to describe the interaction between the different stakeholders as well as the activities performed in each identified case study/scenario, as reported by different researchers (Engels et al., 2005; Knape et al., 2003; Mauro et al., 2010; Eriksson & Penker, 2000; Dijkman et al., 2002).

A more detailed description of the UML notation to develop the use case and the activity diagrams is reported in Appendix.

2.3.1 Use case diagram

In software engineering use case diagrams are to represent missions, task or goals of the different stakeholders involved. The main purpose of this diagram is to list the actors and the use cases and show which actors participate in each use case. The behaviour of each use case is expressed using models of dynamic view such as the activity diagram. A use case diagram contains the following main components:

- The actors, usually individuals involved with the system defined according to their roles and responsibilities. For instance, an actor can be a person, an information system or a device that interacts with the system.
- The use cases, which are the specific functionalities or services provided by the system and performed by actors within and around the system.
- The relationships between and among the actors and the use cases.

Within the MOCHA project the Use Case diagram identifies the actors who interact in the execution of each identified building bock as well as the activities performed. It can be focused on a specific disease or type of intervention. Its description is based of available clinical guidelines that are "systematically developed to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances" (Field & Lohr, 1990). Considering that clinical guidelines are commonly agreed by the scientific community and are therefore important to assess the quality of care, they can be used as a benchmark to compare health care business processes. Other sources that can be used to define a use case diagram are, for instance, evidence-based literature review and/or intervention programs.

2.3.2 UML Activity diagram

The activity diagram is a graphical representation that defines activities as well as actions to be performed in a stepwise manner to model both computational and organizational processes (i.e. workflows) (Rumbaugh et al., 1999). In software engineering the activity diagram is mainly adopted to model business processes captured by a specific use case or scenario at a more detailed level, where each actor involved in the execution of the use case is represented also highlighting the actions carried out. An activity diagram contains the following components:

- Actors who represent a specific user or a system interacting with other stakeholders (as described in the use case diagram, actors can be human being, information systems, medical devices, etc.). This component reflects the actors associated with the specific use case to be described.
- Activities carried out by each actor in a stepwise sequence.
- Messages that can be sent or received, specifying the interaction between two actors.

In a MOCHA perspective this diagram describes the sequence of activities performed and messages exchanged by the different actors as well as triggering conditions of a set of activities within the building block. The description of activity diagrams are based on the case studies provided by the country agents. On the basis of these descriptions we are going to group and then compare countries that have similar procedures, use similar services, are based on similar caregivers for the provision of care.

3 Application of the methodology

This part reports the application of the proposed methodology describing the content of the developed rich picture and of the maps of building blocks. UML use case and activity diagrams describe the asthma treatment, as an example of business process analysis pertaining disease management.

As already mentioned the methodology was presented and discussed in different MOCHA workshops as well as in the Dublin meeting, so that the version presented here also contains the contributions coming from participants' suggestions and comments. Of course, necessary updates and changes may be considered and included in the course of the MOCHA project, especially when we are going to apply it on the case studies that are going to be gathered from country agents. Further developments concerning interaction with social care is already envisioned and under development in collaboration with WP2.

3.1 The rich picture

The proposed rich pictures put at the centre of the model the child represented in figure 2 as a girl jumping from *well-being* to *disease management* and vice versa. Children are generally a healthy

population whose psychophysical development is monitored especially, but not only, in the first years of their lives. When an illness occurs, this is treated following a *disease management* pathway whose results lead to the normal well-being monitoring, or with the management of chronic conditions.

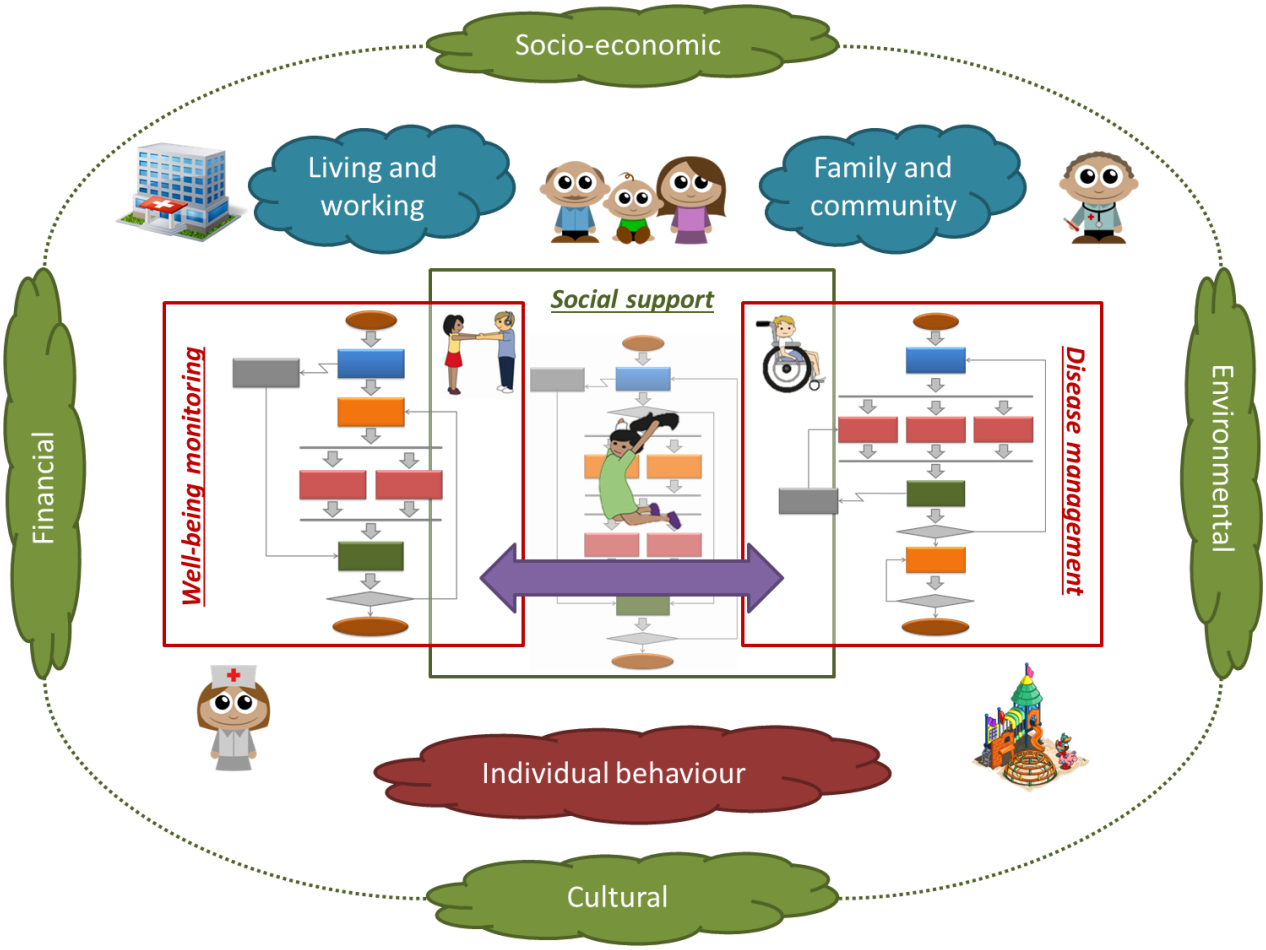


Figure 2: Rich picture highlighting the pathways to be analysed as well as the main determinants of health in the child care setting

These two main pathways are strictly connected with the fulfilment of other child needs address to improve quality of life in terms of social inclusion, ability to live independently, fundamental rights, etc. These needs are met within a third pathway that we call social support that will be detailed in the next deliverable of WP2.

Moreover, these pathways are surrounded by the family and the related living and working conditions, the community as well as health services and professional caregivers. Other determinants of health are identifies in socio-economic and financial conditions, as well as the cultural and environmental settings.

3.2 Map of building blocks

The first refinement of the rich picture focuses on a more detailed high-level description of the three identified pathways, the so-called maps of building blocks: well-being monitoring, disease management and social support. The first two are described in detail in the following paragraphs.

3.2.1 Well-being monitoring

The map of building blocks related to well-being monitoring represents the set of activities carried out to monitor the psychophysical development of an healthy child and/or of children with special conditions or needs, for instance preterm children (figure 3).

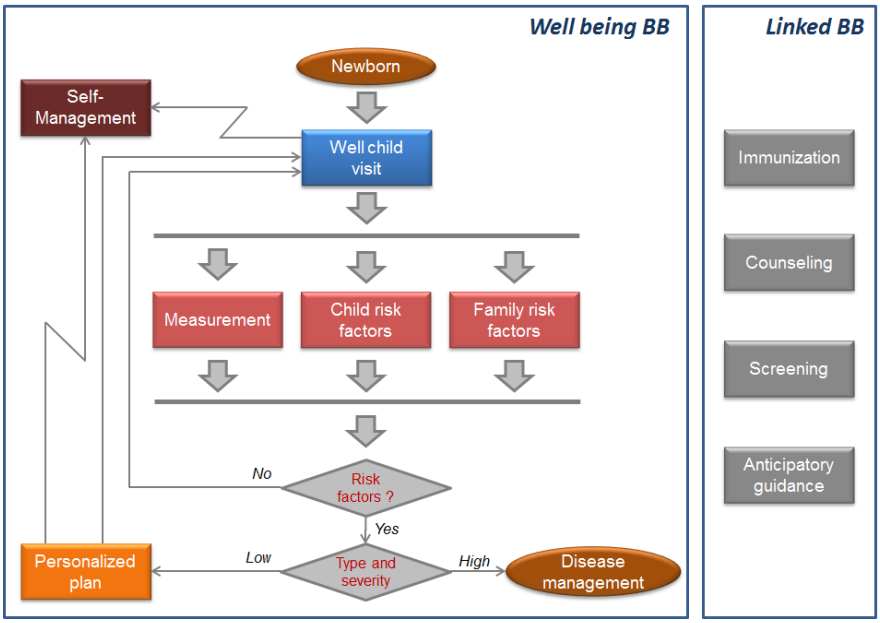


Figure 3: Well-being monitoring map of building blocks

These psychophysical conditions are monitored during the so-called well-child visits performed at specific phases of the child development, with specific frequency varying according to child age and/or guidelines and performed by different care providers, according to national health care systems.

A generic description of the well-child visit includes the workflow of the following macro activities performed in parallel: the measurements of vital signs, the identification of children risk factors, as well as the identification of the family risk factors. If the measurement of the psychophysical development is in line with the age of the child, and if the caregiver does not identify particular risk factors, he/she can schedule the next visit according to guidelines. An important building block is what we call self-management in which the care provider indicates the right lifestyle to be followed, for instance indication about nutrition, physical exercises, etc. If the caregiver identifies a low level of risk factors, he/she may schedule more frequent visits and give a personalised self-plan, for instance in case of premature or obese children. When the risk factor is high, there is a connection with the disease management pathway, described in the following paragraph.

In addition to the psychophysical monitoring of the child, this map contains some linked building blocks performed in the area of prevention and counselling.

A list of building blocks and related meaning is provided in the tables 2 and 3. When available, sources of definitions are reported.

Table 2: Building blocks of Well-being monitoring

Name	Description	Source
Well-child visit	Routine doctor visits that occur during a child's first years of life and annual visits until age 21. These visits include physical exams, measurements, vision and hearing screenings and oral health risk assessments.	UPMC, USA http://www.yourhealthcaresimplified.org/glossary/well-baby-and-well-child-visits/

Measurement	Each visit includes a complete physical exam. At this exam, the health care provider will check the child's growth and development in order to find or prevent problems.	U.S. National Library of Medicine https://www.nlm.nih.gov/medlineplus/ency/article/001928.htm
Check of risk factors	Each visit includes the assessment and identification of potential risks (ex. weight in preterm children)	
Family risk factors	Each visits includes the assessment and identification of potential risks related to parents health (ex. obesity)	
Self-management	Set of recommendations given by the health care provider to support the psychophysical child development (ex. appropriate diet for age, breast feeding, etc.)	
Personalised plan	Set of recommendations given by the health care provider related to a child potential risk assessment (ex. appropriate diet for a preterm child)	

Table 3: Additional building blocks linked with well-being monitoring

Name	Description	Source
Immunization	Immunization is the process whereby a person is made immune or resistant to an infectious disease, typically by the administration of a vaccine. Vaccines stimulate the body's own immune system to protect the person against subsequent infection or disease.	WHO http://www.who.int/topics/immunization/en/
Screening	Screenings are tests that look for diseases before you have symptoms. Screening tests can find diseases early, when they're easier to treat.	https://www.nlm.nih.gov/medlineplus/healthscreening.html
Counselling	The process of assisting and guiding clients, especially by a trained person on a professional basis, to resolve especially personal, social, or psychological problems and difficulties.	Oxford Dictionary
Anticipatory guidance	Specific to the age of the patient, it includes information about the benefits of healthy lifestyles and practices that promote injury and disease prevention.	http://www.atsdr.cdc.gov/emes/training/page19.html

3.2.2 Disease management

The disease management building block represents a high-level conceptual description of a set of activities carried out for the treatment of any type of disease (figure 4). The process starts with a health issue, which is evaluated during the so-called sick visit. Each sick visit is composed by a set of activities performed to make a diagnosis and prescribe the related therapy. Similarly to the well-child visit, the care giver provides indications on the correct way of treating the health issue in terms of medication and/or nutrition, precautions etc. in a self-management plan. A check visit is then performed to verify whether the diagnosis is correct or the therapy is appropriate. If this is not the case the caregiver can change the diagnosis or therapy or both. If the health issue is healed, the child exits this disease management process and comes back to well-being monitoring process. If the health issue is not solved, it is necessary to plan long-term, follow-up activities. This is generally the case of chronic patients, represented here by the maintenance building block.

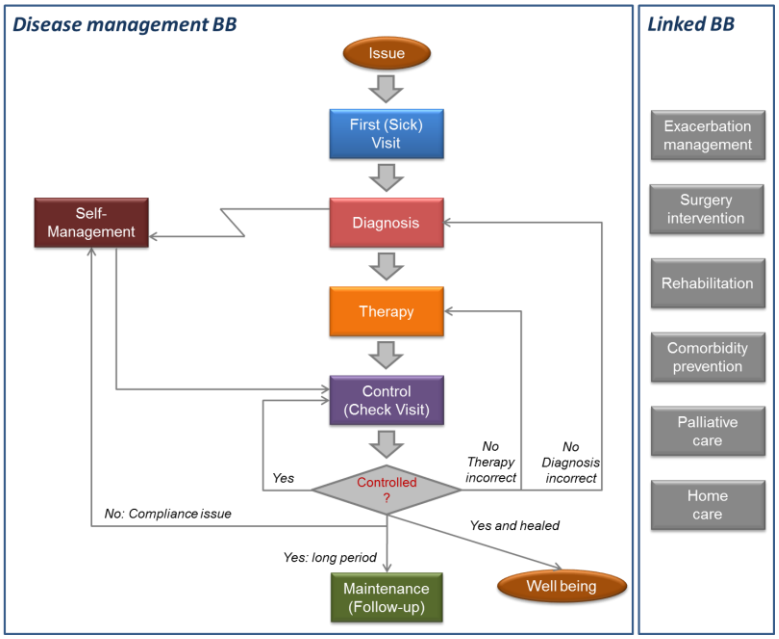


Figure 4: Disease management map of building blocks

The process of disease management comprises various linked building blocks that can represent the connection between primary care and secondary care, and/or the treatment of children with complex needs. The linked building blocks identified so far represent the management of exacerbation that may need for instance hospitalization, prevention of comorbidities, rehabilitation activities to restore physical or mental abilities, or surgery procedure in case of injury or palliative care to improve the quality of the child life in a serious or life-threatening disease.

A list of building blocks and related meaning is provided in the tables 4 and 5. When available, sources of definitions are reported.

Table 4: Building blocks of well-being monitoring

Name	Description	Source
First sick visit	A visit focused on one particular acute problem, such as earache, sore throat, fever, vomiting/diahrrea.	http://www.dukechildrens.org/services/primary_care/visit_types/#sick_child_visit
Diagnosis	The process of identifying a disease, condition, or injury from its signs and symptoms. A health history, physical exam, and tests, such as blood tests, imaging tests, and biopsies, may be used to help make a diagnosis.	NCI dictionary of cancer terms
Therapy	Treatment intended to relieve or heal a disorder	Oxford dictionary
Control visit	A visit focused on the evaluation of the child health status that checks the validity of the diagnosis and the effects of the therapy.	
Maintenance /follow-up	Monitoring a child's health over time after treatment, after a chronic disease has been diagnosed	
Self-management	Set of recommendations given by the health care provider to support the psychophysical child development (ex. appropriate diet for age, breast feeding, etc.)	

Table 5: Additional building blocks linked with disease management

Name	Description	Source
Exacerbation management	Set of activities that manage the increase in the severity of a disease or its signs and symptoms.	
Surgery procedure	A procedure to remove or repair a part of the body or to find out whether disease is present. An operation.	NCI dictionary of cancer terms
Rehabilitation	A process to restore mental and/or physical abilities lost to injury or disease, in order to function in a normal or near-normal way.	NCI dictionary of cancer terms
Comorbidity prevention	Set of activities aiming to prevent the coexistence of two or more diseases	
Palliative care	Care given to improve the quality of life of patients who have a serious or life-threatening disease. The goal of palliative care is to prevent or treat as early as possible the symptoms of a disease, side effects caused by treatment of a disease, and psychological, social, and spiritual problems related to a disease or its treatment. Also called comfort care, supportive care, and symptom management.	NCI dictionary of cancer terms

3.3 UML use case diagram

The identified building blocks of the disease management are further detailed in the UML use case diagram describing a sick visit for asthma treatment. This description is based on the GINA (Global Initiative for Asthma)[2] and BTS (British Thoracic Society)[3] guidelines. Figure 5 depicts a use case diagram that describes the first sick visit building block performed by a primary care physician to verify whether the symptoms suffered by a child are due to asthma pathology.

[2] www.ginasthma.org
[3] https://www.brit-thoracic.org.uk/guidelines-and-quality-standards/asthma-guideline/

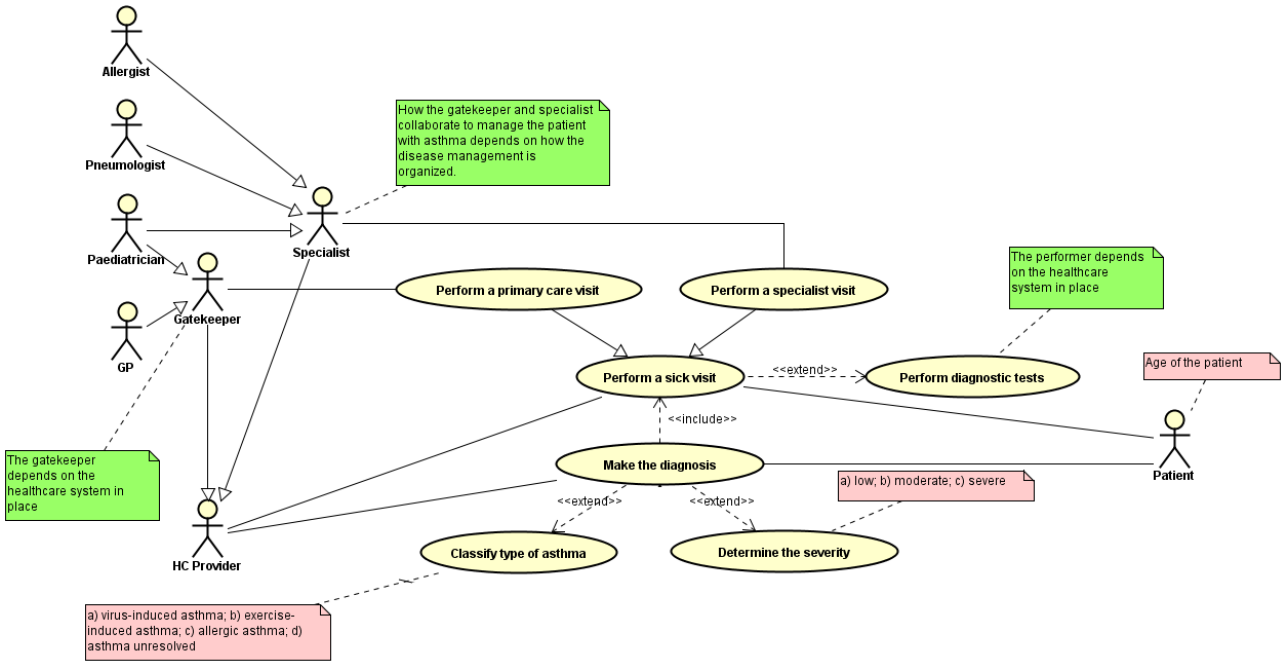


Figure 5: UML use case diagram describing the a sick visit performed for the treatment of asthma

The main actors involved in this part of the process are the Patient and the Health care (HC) Providers, in particular they can be specialized in two relevant actors: the Gatekeeper that can be a GP or a Paediatrician depending on the health care system in place (for instance, Italy is a paediatrician-based system, whereas the UK is a GP-based system). The gatekeeper is responsible for the first visit of the child as well as for the diagnosis that is *included* within the activities of the sick visit. Two important use cases that *extend* the diagnosis activity are the classification of type of asthma and the determination of its severity. Considering the Specialist, that is mainly involved in the performance of a specialist visit, it can be generalized into a Pneumologist or Allergist each one involved in the diagnosis of a specific type of asthma. Moreover, also a Paediatrician can be a specialist, for instance, if he/she belongs to a secondary care organization, a hospital or an emergency room. In the use case diagram it is not possible to highlight certain types of relationships among the actors. For this reason, we add the green notes to explain additional information over the diagram. For instance, the age of the child that is a fundamental variable to discriminate the type of instrumental test to be performed and/or the child and family risk factors to be analysed. Moreover, a note is reported to highlight specificity in national health systems given by the collaboration of the gatekeeper with a specialist to manage the child with asthma. Another example of the distinction among countries is the identification of the caregiver who performs the diagnostic (instrumental) tests (i.e. spirometry). Finally, as described above, also the identification of the gatekeeper depends on the care system in place, such as paediatrician-based system in Italy and GP-based system in UK.

3.4 UML activity diagram

Figure 6 shows the activity diagram for the use case selected: *make a diagnosis*. The diagram is based on a ten years old child who has occasionally experienced wheezy attacks. To make a diagnosis the child has to perform a spirometry test.

Once the gatekeeper has assessed the child respiratory symptoms as well as the child and family risk factors, he/she can perform the spirometry test that is used along with the other non-instrumental

tests to determine the type and the severity of asthma or, in case that the results do not support this disease, to require additional tests or tests that are specific to other pathologies. Also in this diagram some notes are reported to specify information that cannot be reported using the symbols of the UML formalism. In this case they reflect exactly the ones reported in the use case diagram highlighting the different types and severity of asthma.

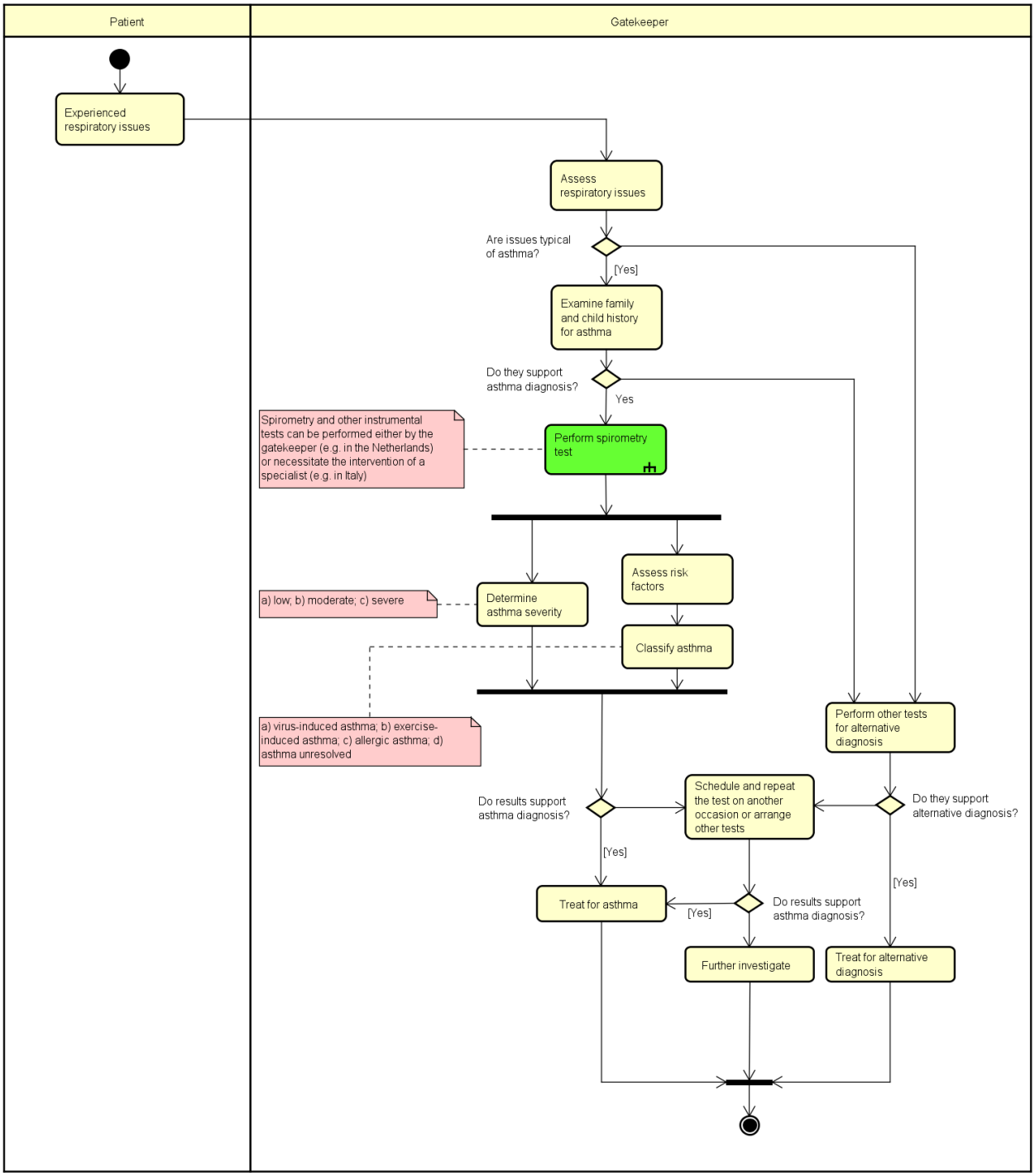


Figure 6: Activity diagram specifying the sequence of activities performed during the diagnosis use case

In this activity flow, the event *perform the spirometry test* is reported in green and as a call activity using the UML formalism. In our example, this activity is an important part of the macro-process as the

spirometry test can be performed directly by the gatekeeper or by a specialist. Therefore, we can distinguish the countries in these two groups and compare the activities performed in each one.

In particular figure 7a the child is required to execute the spirometry test directly during the first sick visit performed by the gatekeeper. In this case the gatekeeper can also analyse the results of this test and make the diagnosis at the first onset of the health issue.

Differently, in the scenario modelled in figure 7b the spirometry is performed by a specialist, for instance in countries where the gatekeeper is not equipped with spirometer or is not qualified to perform this task. Thus, in the diagram the introduction of the third actor (specialist) is needed and visualised using the relevant swim lane. In particular, the gatekeeper requires the family of the child to book a specialist visit during which the required test is performed. This implies the collaboration between the two health care professionals as well as the inclusion of administrative procedures related to the booking and eventually payment of the specialist visit.

The two processes are compared not only on the basis of activities performed and actors involved but also on the time required to perform the diagnosis. In the second scenario this implies also to include waiting time for a child to access to the primary as well as to the secondary care visit, as shown by the hourglass reported in the diagram 7b.

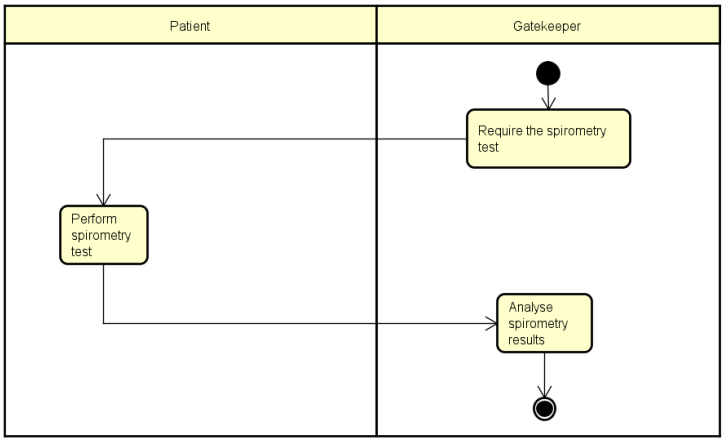


Figure 7: Activity diagram describing the performance of the spirometry test executed by the gatekeeper

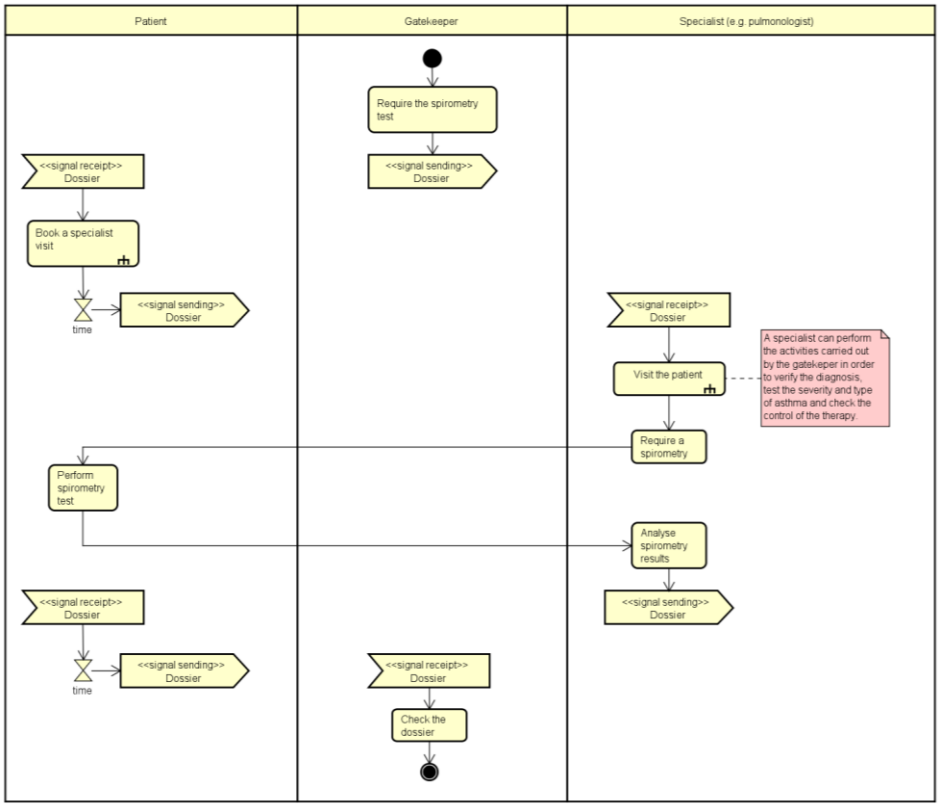


Figure 8: Activity diagram describing the performance of the spirometry test involving the specialist (e.g. pneumologist)

4 Conclusion and discussions

This deliverable describes the methodology proposed to make a comparison between the different business processes performed in 30 EU countries in the delivery of child care. It is not based on pre-defined models of care, which are very difficult to identify a priori, but is quite flexible to allow the comparison between a set of homogeneous building blocks that are identified in the context of three main pathways: well-being monitoring, disease management and social support. The identification of building blocks that may be enriched in the course of the MOCHA project can also represent the interaction between primary and secondary care or primary and social care services.

The methodology also specifies how UML use case and activity diagram are adapted to achieve the comparison of business processes across countries, identifying the sources of information on which the descriptions are going to be based. In particular use case diagram will provide a snapshot of actors and activities related to a building block and will rely on clinical guidelines that represent a benchmark to compare health care business processes. Activity diagram will take advantage of the MOCHA case study approach to highlight differences and similarities in activities performed, actors and services involved as well as timelines "in real-life context" (Crowe et al., 2011).

A first application of this methodology has been reported considering the asthma management as an example, where the activities of performing a spirometry test directly by the gatekeeper are compared with those performed by the pneumologist.

References

Al-Debei M.M., El-Haddadeh R., Avison D. Defining the business model in the new world of digital business. In Proceedings of the Americas Conference on Information Systems (AMCIS), 2008, pp. 1-11.

Breu R., Grosu R., Huber E., Rumpe B., Schwerin W. Systems, views and models of UML. In The Unified Modeling Language, 1998, pp. 93-108.

Checkland P. Systems Thinking, Systems Practice. JohnWiley and Sons, New York, 1981.

Checkland P. From optimizing to learning: A development of systems thinking for the 1990s. Journal of the Operational Research Society, 1985, 757-767.

Checkland P. Scholes J. Soft Systems Methodology in Action. John Wiley and Sons, Chichester, 1990.

Checkland, P. Soft systems methodology: a thirty year retrospective. Systems Research and Behavioural Science, 1998, 17, S11–S58.

Coad P. Object-oriented patterns. Communications of the ACM, 1992, 35.9, pp. 152-159.

Crowe S, Cresswell K, Robertson A, Huby G, Avery A, Sheikh A. The case study approach, BMC Medical research Methodology, 2001, 11: 100.

Darzentas J, Spyrou T. Information systems for primary health care: the case of the Aegean islands. Eur. J. Inf. Systs, 1993, 2.2, pp. 177-127.

Dhara K.M., Dharmala M., Sharma C.K. A Survey Paper on Service Oriented Architecture Approach and Modern Web Services, 2015.

Dijkman R.M., Joosten S.M.M. Deriving use case diagrams from business process models, Technical Report 02-08, CTIT, Enschede, The Netherlands, 2002.

Engels G., Förster A., Heckel R., Thöne S. Process modeling using UML. Process-Aware Information Systems, 2005, pp. 85-117.

Eriksson H., Magnus P. Business modeling with UML. Business Patterns at Work, John Wiley & Sons, New York, USA, 2000.

Field M.J., Lohr K.N., editors. Committee to Advise the Public Health Service on Clinical Practice Guidelines, Institute of Medicine. Clinical practice guidelines: directions of a new program. Washington, DC: National Academy Press; 1990.

Knape T., Hederman L., Wade V.P., Gargan M., Harris C., Rahman Y. A UML approach to process modelling of clinical practice guidelines for enactment. Studies in health technology and informatics, 2003, pp. 635-640.

Kruchten, P. Architectural Blueprints — The "4+1" View Model of Software Architecture, IEEE Software, 1995, pp. 42-50.

Kumarapeli P., De Lusignan S., Ellis T., Jones B. Using Unified Modelling Language (UML) as a process-modelling technique for clinical-research process improvement. Medical informatics and the Internet in medicine, 2007, 32(1), 51-64.

Mansour H., Karabey F., Amaldi P. Successful redevelopment of e-Government systems: Outcomes determined by system engineering approaches. User Involvement in e-Government development projects, 2005, 29 http://creativeconnection.co.uk/case-studies/coastal-west-sussex-ccg/

Mauro C., Happle T., Sunyaev A., Leimeister JM., Krcmar H. From medical processes to workflows: modeling of clinical pathways with the unified modeling language. In Third International Conference on Health Informatics, 2010, pp. 388-391.

McGeorge D., Chow V.W., Carthey J., Loosemore M. Modelling the impact of extreme weather events on healthcare infrastructure using rich picture diagrams. In Association of Researchers for Construction Management (ARCOM) Conference, Bristol, 2011.

McLeod G. The Difference Between Process Architecture and Process Modeling/Design, 2011.

Monk A., Steve H. The rich picture: a tool for reasoning about the work context. Magazine Interaction, 1998, 5(2), pp. 21-30.

Müller J.K. The Building Block Method; Component-Based Architectural Design for Large Software-Intensive Product Families, Amsterdam, 2003, http://www.gaudisite.nl/proefschrift_jkm_bbm.pdf.

OpenLearn, The Open University on OpenLearn. Diagramming for development 1 - Bounding realities, Available at: http://www.open.edu/openlearn/science-maths-technology/computing-and-ict/systems-computer/diagramming-development-1-bounding-realities/content-section-3.1, 2012

REQB. Requirement engineering qualification board. Standard Glossary of terms used in Requirements Engineering, v. 1.4, 2015, Available at http://reqb.org/

Rumbaugh J., Jacobson I., Booch G. The Unified Modeling Language Reference Manual. Addison-Wesley, 1999.

Rumbaugh J., Jacobson I., Booch G. Unified Modeling Language User Guide, The (2 ed.). Addison-Wesley, 2005.

Russell N., ter Hofstede A., Van der Aalst W., Wohed P. On the Suitability of UML 2.0 Activity Diagrams for Business Process Modelling. In: Conceptual Modelling. Proceedings of APCCM2006, 2006, Australia, Tasmania, Hobart.

Sommerville I. Software Engineering (7 ed.). Pearson Education, 2008.

Suitts M. The Building Blocks of Professional Development (And Why You Should Care). http://blog.cetrain.isu.edu/blog/bid/357190/The-Building-Blocks-of-Professional-Development-And-Why-You-Should-Care, 2014.

TOGAF® Version 9.1, Enterprise Edition; http://pubs.opengroup.org/architecture/togaf9-doc/arch/, 2011.

Vasilakis C., Lecnzarowicz D., Lee C., Application of Unified Modelling Language (UML) to the Modelling of Health Care Systems: An Introduction and Literature Survey. International Journal of Healthcare Information Systems and Informatics, 2008, 3(4), pp. 39-52.

WHO, Monitoring the building blocks of health systems. A handbook of indicators and their measurement strategies, 2010.

Appendix 1. UML notation.

This appendix describes the notation of the use case (table A1) and the activity diagram (table A2).

Table 6: Graphical elements of the use case diagram

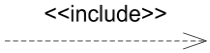
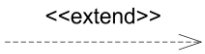
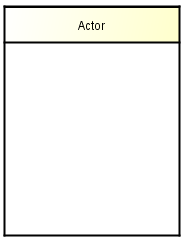
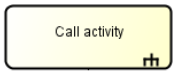
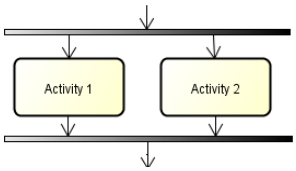
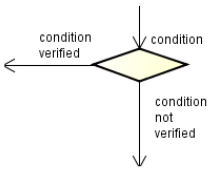
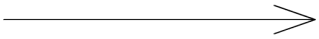
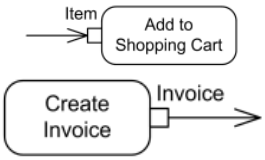
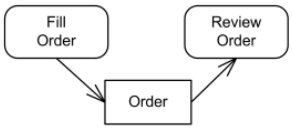
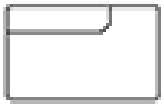
Element description	Symbol used in the UML formalism
Actor: represented by a stick man it indicates the actors and stakeholders that take place in the process to be modelled. An actor can be a person, an information system, a device, etc.	
Use case: represented by an ellipse it defines the single use case implemented in the process representation to be modelled.	
Generalization: also known as a parent-child relationship is used when different uses cases have commonalities in behaviour, structure, and purpose. For instance, the use cases describing the performance of different specialist visits such as neurological, allergic, urologist, oncologist (children) can be generalized in the more general use case "Perform a specialist visit" (father). This relationship is represented by a solid line that starts from the child class and ends to the parent class using a solid line with an unfilled arrowhead. The same relationship is also applied to generalize actors. For instance a neurologist, urologist, allergic and oncologist can be generalized in a "Specialist" actor. In this case all the use cases managed by a father are inhered and can be managed also by the children.	
Include: represented by a dashed arrow labelled with a the stereotype <<include>> it relates two use cases when the behaviour of the included use case (end of the arrow) is part of the base use case (begin of the arrow). It is mainly applied to reuse common actions across multiple use cases as well as to simplify complex process by split them into several use cases. In this relationship the included use case is mandatory and the base use case is incomplete without it. For example, the "Hospitalization" of a patient (base use case) shall comprise his/her "Registration" (included use case).	
Extend: represented by a dashed arrow labelled with a the stereotype <<extend>> it relates two use cases when a set of functionalities included in the extended use case (begin of the arrow) are added to a base use case (end of the arrow). For instance, the use case "Perform a Visit" enhances the functionalities of the "Perform diagnostic test" use case. When performing a use case the execution of extending use cases is optional and can be triggered conditionally.	
Association: represented by a solid line it associates an actor with one or more use cases taking into account that an actor must be associated with one or more use cases and that each use case can be associated with one or more actors.	
Note: represented by a rectangle with a with a top-right corner bent it allows the diagram creators or collaborators to communicate additional messages that don't fit within the diagram itself. Each can be related to a specific actor or use case of the diagram.	

Table 7: Graphical elements of the activity diagram

Element description	Symbol used in the UML formalism
Actor: represented by a swim lane it indicates the actors and stakeholders that take place in the process to be modelled. An actor can be a person, an information system, a device, etc. Each activity performed by the actor is embedded in the relevant swim lane.	
Initial state: represented by a full black circle it indicates the represents the beginning of a process. It can be used by itself or with a note symbol that explains the starting point.	
Activity: represented by a rectangle with rounded corners it defines the single activity performed by the relevant actors of the swim lane where it is placed.	
Call activity (macro-activity): represented by a rake-style symbol within the activity symbol it is used to invoke the execution of an another activity diagram.	
Wait time action: represented by a stylized hourglass it introduces a time related event. The note placed next to the symbol specifies the time at which the occurrence happened. Once the time event occurred the related action should be performed.	
Join: represented by a thick vertical or horizontal line it combines two concurrent activities and reintroduces them to a flow where only one activity occurs at a time.	
Fork: similarly to join it is represented by a thick line it splits a single activity flow into two concurrent activities.	
Concurrent activities: represented by a fork symbol followed by a join symbol it describes the split of the main flows into two or more parallel activities that are subsequently reintroduced in the main flow.	
Decision: represented by a diamond shape it represents a conditional decision at which a workflow divides into two or more branches. The condition is placed next to the connector depending on the branch that matches the relevant answer. The condition (known as the guard of the activity edge) is shown in square brackets.	

Message sent: represented by a convex pentagon labelled with a <<signal sending>> stereotype it describes a signal generated and transmitted to an identified actor, when all the prerequisites of the action execution are satisfied.	
Message received: represented by a concave pentagon labelled with a <<signal receiving>> stereotype it describes a signal received by an actor. Each message received shall be accompanied by a message sent.	
Final state of the flow: represented by an empty circle with a cross inside it shows the ending point of a single process' flow.	
Final state of the process: represented by a solid circle with a hollow circle inside it represents the completion of the whole process. While final state of the flow identifies the end of a process in a single flow, a final state of the process represents the completion of all flows in an activity diagram**.**	
Connector: represented by an arrowed line that shows the directional flow, or control flow, of a set of activities, messages, initial and states, etc. An incoming arrow starts a step of an activity; once the step is completed, the flow continues with the outgoing arrow.	
Interrupting connector: represented by a zig-zag arrow it is used to manage an exception that can occur during the execution of a relevant activity.	
Input and output pin: represented by a small square attached to the activity rectangle it represents objects (such as information, document) that are inputs or outputs of the relevant activity.	
Object: represented by a rectangle it describes an object (such as information, document) that is exchanged between two activities.	
Loop: represented by a rectangle with a label on its top-left part it allows the creator to model a repetitive sequence of actions within the option loop symbol.	
Note: represented by a rectangle with a top-right corner bent it allows the diagram creators or collaborators to communicate additional messages that don't fit within the diagram itself. Each can be related to a specific element (activity, message, actor, etc.) of the diagram.