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RESEARCH ARTICLE

PROPOSITION OF A KNOWLEDGE MODEL OF THE MATERNITY UNIT.

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Abstract

The maternity unit is of great interest in the hospital systems because it is urgent and delicate. Hence, the best management requires the dimensioning of the human and physical resources. To deal with this complexity, we followed the following methodology ASDI (Analysis, Specification, Design, Implementation). The aim of this article is to propose a generic knowledge model of the maternity service with the ARIS tool and the UML language in order to design and to implement a decision support tool.

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Introduction:

Nowadays the hospital systems face the same constraints as the industrial companies, particularly in terms of quality. Indeed, the hospital systems must provide the optimal service to the patient. Different human and physical resources are implemented for this purpose and are available in limited capacity. So the hospital systems combine them even many systems with distinct characteristics. These systems include for example: the care units, the management of emergency services, the medical-technical equipment, the patient transport services, the consulting services, the imaging services, the logistic, the service biology (laboratories ...) and the technical and the administrative services. In our work we are interested in the maternity unit.

Assessing the hospital performance as indispensable for the hospital managers to help them to take decision about resources (whether human or physical) and to detect their under or overuse. The performance assessment can be solved using modeling and simulating tools. For instance, there have been, on the one hand, numerous works dealing with the aspects of modeling, methodology, performance indicators, like (Besombes and al., 2004; Belaidi and al., 2006; Ducq and al., 2004).

On the other hand, in the literature and excluding the medical publications, few works treat the maternity and the obstetrics block. This «stinginess literary» is partly explained by the complexity of the system that collects different activities like (emergency consultations, deliveries, medical abortions...) but especially it is difficult to predict. The maternity unit seems a structure which includes the sectors of operating modes, the technical levels which are completely different (for example the consultation room, the delivery room, the operating room ...) and it involves many physical and human resources (like doctors, midwives, anesthetists, nurse anesthetists ...). To improve the performance of the maternity unit, it would be interesting to manage the dimensioning of the physical and the human resources. To achieve this goal, we offer a tool to the decision. To design such a tool, we are adopting a modeling approach. Modeling the hospital systems have specific features compared to the modeling of industrial systems mainly the nature of the clients. For example, in industrial systems the pathway patient is known in advance against in hospital systems it depends on the condition of patients and human and physical resources, the beginning and the

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end of treatment and various management rules. These specificities must be taken into account during the modeling phase (Rodier and al., 2014).

In this paper, we will explain in the second section a state of the art and the specific characteristics of maternity before presenting in the following section the methodology, the tools and languages that we followed for the construction of a general knowledge model. In the fourth section we give the knowledge model of the maternity service. We conclude by giving some perspectives for the future works.

States Of The Art and Specificities Of The Maternity Service:

In our work, we try to focus on the maternity unit. This service is of great interest in the hospital systems because of its urgency and delicateness. In many countries of the world, the quality of care in this service constitutes a major public health priority for improving the reproductive health.

The maternity service is an unpredictable and a difficult programmable service: for example pregnant women are welcomed in the service throughout the day and throughout the year. The maternity service appears as a structure that brings together the different sectors and modes of the functioning with specific technical services such as (consultation room, delivery room, operating room ...) and it involves many physical and human resources, (doctor, midwife, anesthetist, theater nurse, nurse anesthetist ...).

The maternity ward is considered the structure where are greeted pregnant women to receive counseling and medical treatment for their support. For obstetric emergencies, two solutions are presented such as the reception in general emergencies and immediately the orientation to the obstetrics unit and to the reception at the maternity

This service is characterized by the following particularities. Firstly, the evolution of the treatment of the patients where it is frequent that the patient who comes to an emergency consultation is redirected towards the delivery area or to an operating room to receive a Caesarean. The obstetric activity remains one of the most random among those in the hospital field systems. Secondly, the number of human resources by activity knowing that the caesarean activity can mobilize up to eight human resources and even more in the case of multiple births. Thirdly, the complexity of management of the queue because the maternity service has few planned activities but especially many random activities (like consultations and emergency deliveries ...). Prioritizing activities and patients, and therefore the management of queues, can then be complex when the activity is important. Finally, the evolution of planning's functioning: the maternity services should be open 24h / 24h to accommodate all patients. The functioning planning's resource attached there can then vary depending on the activity being performed.

To improve the performance of this service, it would be interesting to examine the logistics that is interested in the management of the material flow and the logistics which cover the patient management flow. The choice of different types of flow resulted from the fact that they are cross linked.

We are particularly interested in the concept of "patient pathways" which is a concept to focus and unify the activities around a single issue: the patient's stay. This stay should be as short and as efficient as possible in accordance with the medical indications, comfort and the patient safety as well as the quality of the services provided.

For the patient course, we mean the patient journey from entering the system to his output, bringing together all the treatment he benefits. During this process, we identify different problems on several levels. First, at the level of patient pathways, the complexity to take into account the complex and non-linear path because the use of probabilities and management rules that is specific to the path but also to treatments that make up. Second, at the level of activity, complexity requires highly accurate modeling of many attributes that take into account all the specifics of each individual treatment and the implementation of the corresponding management rules (priority treatment, authorized or not to interrupt treatment ...).and third, at the level of resources, particularly the human resources, complexity is reflected in the assignment rules of medical and paramedical staff.

By analyzing the literature on the hospital systems and particularly the maternity service, we released the following various problems. The organizational issues including Support times can be very long for patients especially cesareans, the complexity of queues managing, the maternity ward includes some scheduled activities but especially many random activities (consultations and emergency deliveries ...), prioritizing activities and patients, and therefore

the management of queues, can then be complex when the activity is important, the waiting time before patients supported, lack of beds and random application stretched, the operating room is occupied, the lack of the medical and the paramedical staff, the personalization of the human resources where this is possible (depending on schedules and emergency) as it is important then the medical staff that monitors the patient (obstetrician, midwife) is the same from his entry until his release.

There is also Attendance problems including the random arrival of the patients both daily and nightly. The evolution of the treatment of patient: it is often that a patient who comes to an emergency consultation is redirected towards the delivery room or to an operating room to receive a Caesarean.

Moreover, in the literature, there are few studies that deal with the modeling of maternity service. In (Centeno.al, 2001), the authors studied the maternity service. A flow diagram has been established, modeling patient pathways of deliveries and appointments for examinations or interventions. The system processes the stochastic and the deterministic arrival process.

In (Rezg.al, 2010), the authors developed a decision support platform maternity at home. This platform, designed from the modeling method ASDI (Analysis, Specification, Design, Implementation), which develops a knowledge model (Petri net) and an action model (SIMAN / ARENA) implemented in OptQuest for the resource sizing. It will be set up in a hospital in Port-au-Prince.

In (Martha.al., 2001), the authors presented a simulation model in the delivery room of Jackson Memorial Hospital. The simulation model has produced results in order to improve the planning of doctors and to improve the level of the personnel.

We found that the existing work is dedicated to specific problems and not treat the patient pathways of their entries to their exit. In our work we try to model the path of the patients using the ASDI methodology.

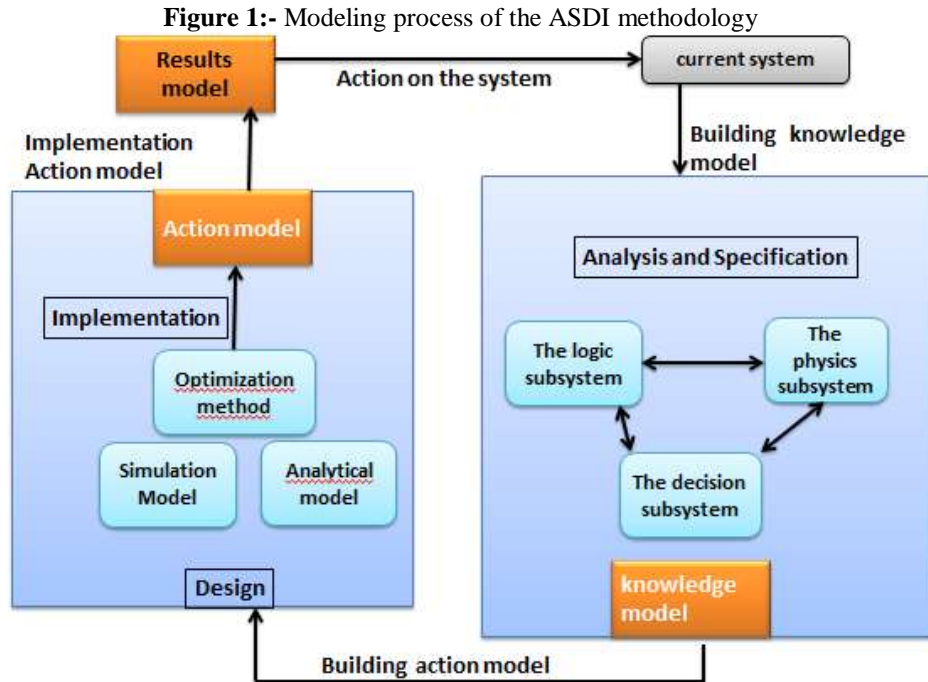
Foundation of the ASDI methodology:-

The methodology (Analysis, Specification, Design, Implementation) (Gourgand and Keller, 1991) was developed in LIMOS and was used primarily for modeling the production systems. This methodology is based on an object-oriented approach for the subsequent construction of two models: a knowledge model which is a formalized knowledge of the system and an action model that represents a translation of the knowledge model in a mathematical formalism or a programming language for the assessment of the performance indicators.

We find in the literature that the ASDI approach has been successfully used in the modeling of complex systems. It was also adapted to the hospital systems. (Mebrel.al, 2006).

The conceptual framework of the ASDI modeling methodology is based on a modeling process which explicitly separates the collection of knowledge from its exploitation. It provides a systemic approach that supports the hierarchical decomposition of a system with the object paradigm in three interconnected and complementary subsystems. To manage the complexity of the hospital systems, we adopt the decomposition into three subsystems: The physics subsystem (PSS) defines all the material and the human resources, the logic subsystem (LSS) consists of the flows that the system must process, sets of the transactions involving these flows and the decision subsystem (DSS) that contains the management and the working rules of the system contains the rules for the management and operation;

While there is no redundant information among the three subsystems, there are functional relations between them. Figure 1 summarizes the system modeling process based on the ASDI methodology.



The ASDI methodology is used in many fields. (chabrol and al.2006a), used this methodology in the urban traffic systems for their piloting and optimization. To model and to simulate the units of care, (Chauvet, Kemmoe, and Aleksy, 2008) adopted the ASDI methodology within the framework of the future hospital of Estaing de Clermont Ferrand. The authors focused on the dimensioning in terms of the number of units of care.

Based on the ASDI methodology, ((Chabrol, Gourgand and Rodier (2008a) suggest a heuristic-based decision support tool for the design and the planning of the operating units.

(ROYER, 2014) proposes a new approach inspired by the ASDI methodology helping hospitals and pharmacists to manage the drug circuit in the hospital's pharmacies.

(Germain, 2012), applied the methodology ASDI to quantify in an optimal way the human resources that will be part of the "maternity home care assistance" team;

Approach Of Construction Of General Knowledge Model :-

In this paper we begin with the first phase which is to specify and to analyze our system to build the knowledge model.

The formalism used to build the knowledge model:-

(Trilling, 2006), author's purpose to classify the methods, the methodologies, the reference architectures and the frameworks for the model into four categories: first, we can start with:

The structured approaches:-

Based on the principle of the top-down decomposition. It is modular, hierarchical that captures the complexity of a system. Among the best known we can mention SADT (Structured Analysis Design Technique) and the family of IDEFx methods.

Second, the systemic approaches:-

Focused on the interaction of systems and particularly on the flow analysis: MERISE, GRAI (Graph results and interrelated activities), GIM, PERA (Purdue Enterprise Reference Architecture), CIMOSA (CIM Open System Architecture) GERAM (Generalised Enterprise Reference Architecture and Methodology)

Third, the process-oriented approaches:-

Based on the analysis, the reorganization of the systems and the processes implemented in the company: ARIS (Architecture of Integrated Information Systems), SCOR (Supply Chain Operations References).

Finally, the object-oriented approaches:-

OMT (Object Modeling Technique), OOD (Object Oriented Design), OOSE (Object-Oriented Software Engineering), UML (Unified Modeling Language).

Thus, the choice of the tools and the languages for modeling is an inevitable step. In this paper, we try to follow two approaches. First, a process-oriented approach to model the patient pathways that includes the stakeholders functions. Our choice fell on the ARIS method. ARIS provides an intuitive graphical representation of the patient pathways via Event-driven Process Chain (EPC). The EPC are used to represent the relationship between the views of data objects and the functions. The sequence of functions in the sense of the process (patient pathways) was represented by EPC presenting trigger events and their consequences for each function. Second, An object-oriented approach to model the systemic decomposition of the system into three sub systems: the physic subsystem, the logic subsystem and the decision subsystem. We chose the UML modeling language that has the advantage of a formal language, standardized and easily comprehensible. To present the different subsystems we used the class diagrams.

General Knowledge Model of The Maternity Service:-

The knowledge model describes the structure and the functioning of the system in a natural or a graphic language. For an existing system, the knowledge model contains the knowledge acquired after observations of the maternity service. The construction of the knowledge model consists in the collection of knowledge and the formalization of the studied service.

We present the following systemic knowledge model and the knowledge model of the patient pathways process.

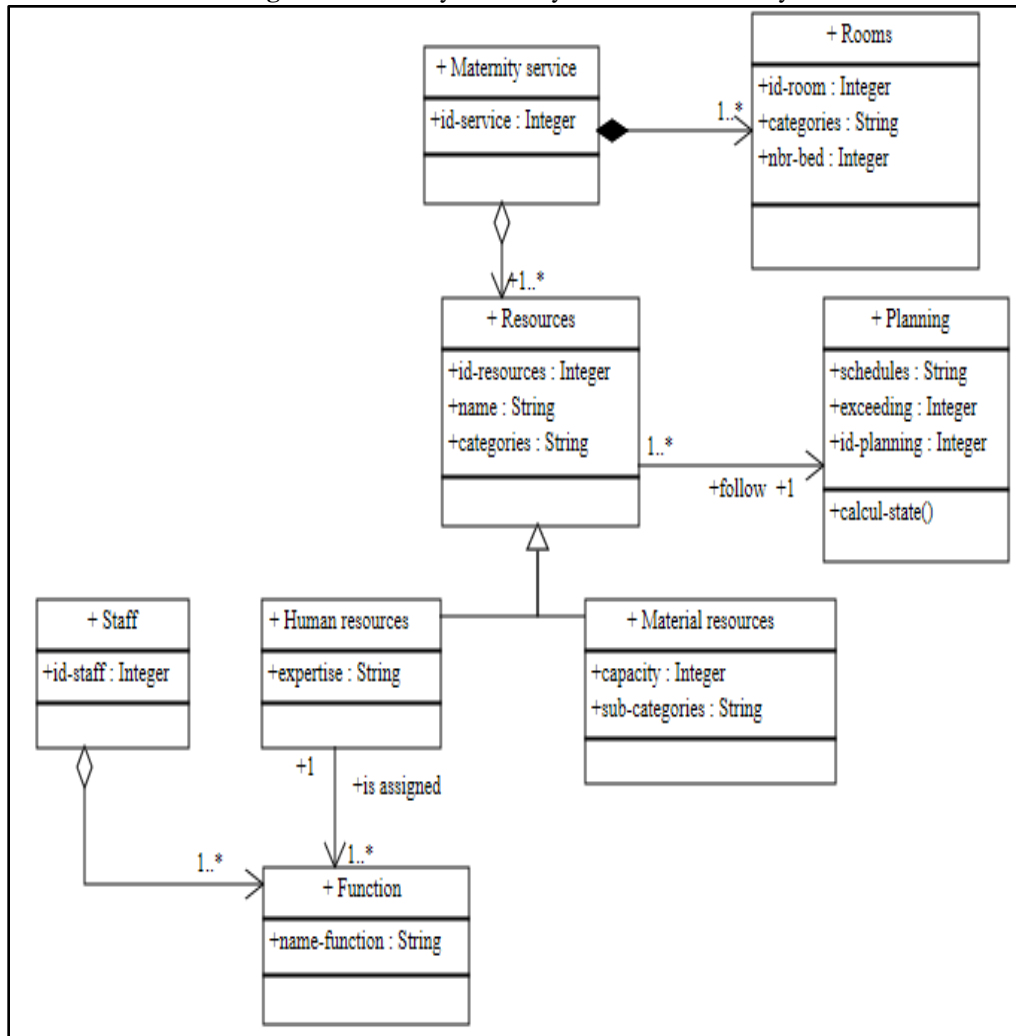
The systemic model:-

In this section we first present the three sub systems of the systemic knowledge model. The Physics Subsystem A physical subsystem has all necessary resources for the implementation of activities on the system load.

The SSP includes all the physical means (the active and the passive resources), their distribution and their interconnections.

The physical subsystem of the maternity is composed of the material resources (the different types of rooms) and the human resources (whether medical or paramedical staff). Figure 2 shows using UML class diagrams all classes and relations of SSP.

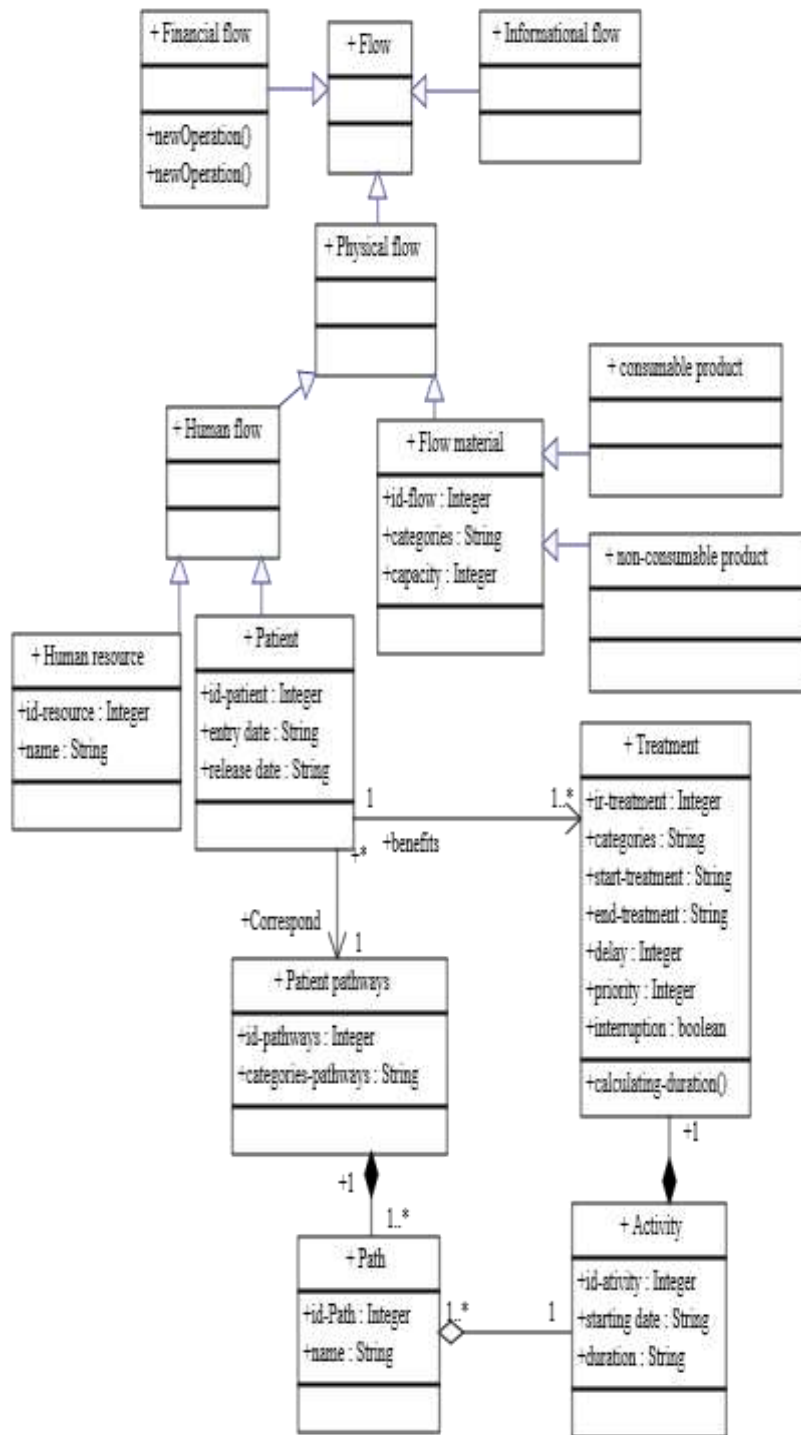
Figure 2:- The Physics Subsystem of the maternity



The logic subsystem:-

Figure 3 shows the use of the UML class diagrams. The logic subsystem includes all the flows crossing the system. We identify three types of flows: physical, informational and financial. Physical flows are composed of the activity flows, the human flows (patients, human resources) and the material flows (products, raw materials ...).

Figure 3:- The logic Subsystem of the maternity



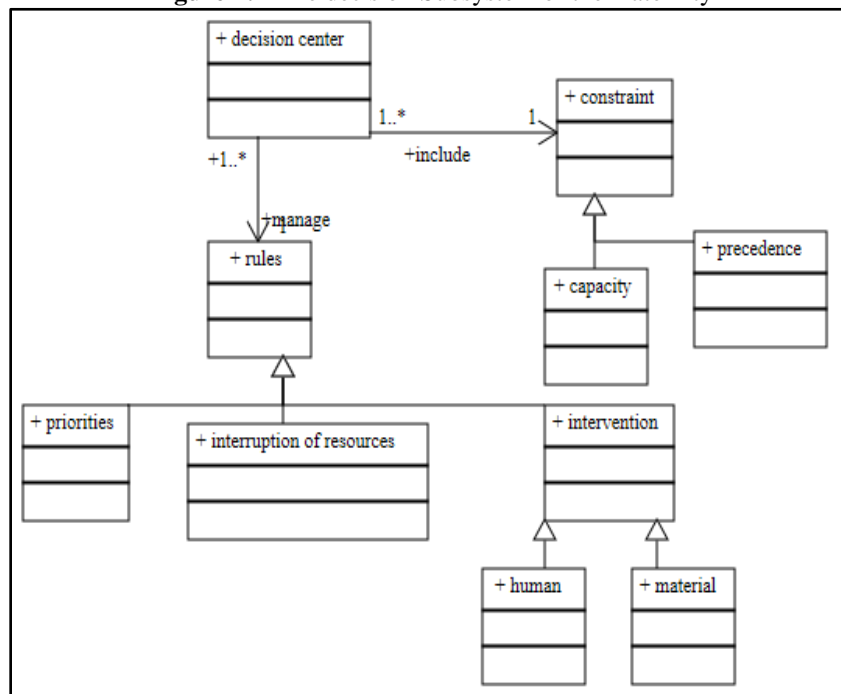
The decision subsystem:-

The decision subsystem is structured in decision centers. It contains all the system operating rules and the algorithms for controlling the system. The implementation of management policies of the system requires the ability to act on the entities of logic subsystem and the physical subsystem based on information from these subsystems. The activities of the decision subsystem are gathering on collecting information from other subsystems (eg. coordinator). We apply the action to the logic subsystem by implementing the rules for the resource allocation decisions and by

acting on the physical subsystem realizing the rules for bad management and the rules for the management of the resource allocation.

The rules for managing the maternity are various and complex. We can classify them into three categories: the resource Intervention (eg resources are used mainly in the area of assignment); the preemption of resources (eg human resources can interrupt an activity to achieve a more important priority activity) and the prioritization of treatments (eg direct care treatment (patient-related) having priority over the others). For an elementary treatment i can preempt the resources occupied by another treatment k . the priority i is high, the treatment k permits the preemption and the use of resources. The operating area is given the priority over the delivery area and it is even prior to the examination area. Figure 4 summarizes the use of the UML class diagrams of the decision subsystem in the maternity

Figure 4: - The decision Subsystem of the maternity



The knowledge model of the patient pathways:-

The knowledge process model shows the patients' pathways which includes the activities from the entry of patients in service until its release. This model completes the systemic knowledge model and is generated from the ARIS tool.

The complexity of the patient pathways is primarily related to the non-linearity, the use of team including a variable number of human resources needed to achieve the same activity up to six simultaneous human resources and the use of probabilities and / or the business rules in each pathway and the "basic operations" within them.

In the ARIS language, the Event Process Chain (EPC) belongs to the process view. The EPC can describe the various processes of the patient pathways using functions and events.

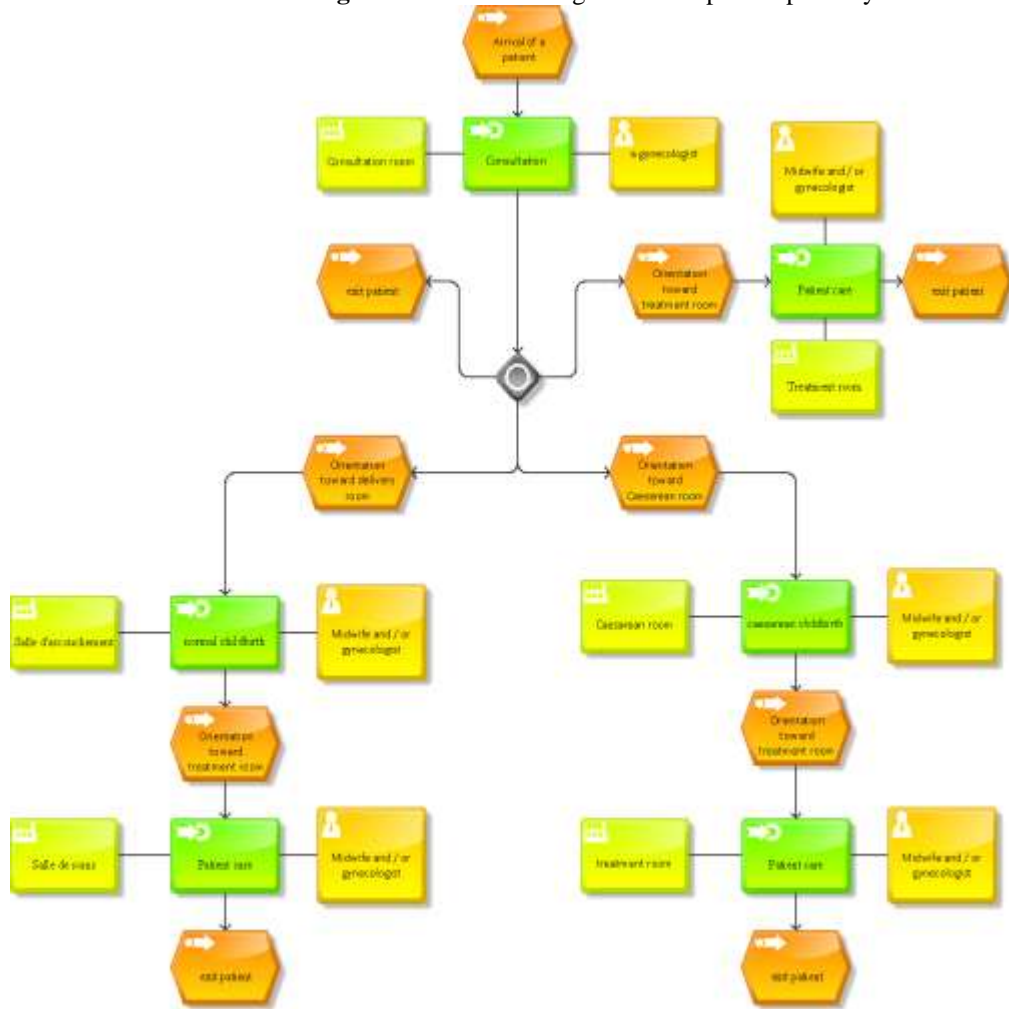
The events determine the status or the condition that triggers a function and the status which marks the finish; the start and ending nodes of such an EPC are always events. An event can cause multiple functions simultaneously and conversely a function can generate multiple events.

The EPC of the general pathways patient in the figure below is composed of four paths:

1. Consultation without continuation of their patient in the consulting room by a gynecologist

2. Consultation of patient in the consulting room by a gynecologist and its orientation to the treatment room and being supported by a gynecologist and/or midwife.
3. After the consultation, the patient is directed to the delivery room to be supported by a gynecologist and/or a midwife (normal delivery)
4. After the consultation, the patient was oriented to the caesarean room to be supported by a gynecologist and: or a midwife (caesarean delivery)

Figure 5:- The knowledge model of patient pathways



Conclusion:-

In this article, we presented the issue of maternity service. Then, we studied the ASDI methodology and its implementation for analysis and study of this service. Then we explained and described the general knowledge model of motherhood under the first two stages of our methodology (analysis and specification).

We envisage prospects mainly concern generation of action model from the knowledge model providing support to the decision on the design of human and material resources maternity.

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