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Section A-Research paper

Using Lean Six Sigma and Artificial Intelligence for improving medical support during maternity

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***Abstract*— During pregnancy, women are often confronted with health problems that require follow-up or even medical treatment to reduce the risk of malformations that can lead to the loss of the baby and the mother.**
According to the WHO, 2.8 million pregnant women and newborns die each year, one every 11 seconds, mostly from preventable causes. In 2017, 290 000 women died during or after pregnancy. [1]
With the emergence of COVID 19, the danger of a severe course of this virus with an increased risk of intensive care admission, intubation, and mortality is significantly higher in pregnant women than in non-pregnant women of the identical age.
When it's the first pregnancy, the lady worries at the slightest sign that seems abnormal, so she goes to her midwife or gynecologist, but within the case that the appointment is complicated to make, she goes to the ER, except that this will increase the workload of the emergency room, therefore, increase the waiting time which will be dramatic in some cases.
To overcome these difficulties, this work aims to measure the maternity in serenity with more comfort and support from health professionals through a decision-making tool that adapts to the state of each woman.
For this, the trail taken from the announcement of the pregnancy to the postpartum period is modeled with BMNP. Then the model will be analyzed to identify areas for improvement.
Finally, a simulation is going to be established to visualize the course of follow-up during the pregnancy and the set of interactions between the parturient and the medical staff which will simplify the decision making and intervene efficiently in case of complication while integrating the choices and the desires of the parturient.

Index Terms*— Artificial intelligence, business process model and notation, decision making, lean six sigma, maternity, process simulation.*

I. INTRODUCTION

The desire to have a child is an ambivalent feeling linked to the history of each person, to the family past, to the child one has been, to the link to the mother and, to the professional context.

In France, most women continue to have a desire for motherhood. It is one of the countries in Europe with the highest fertility rate, with an average rate of 1.83 births per woman in 2021 according to the National Institute of Statistics and Economic Studies [2].

Psychologists agree that subconsciously, some women see motherhood as a "repair" or revenge for a difficult childhood or several disappointments in love. The desire for a child can also be physiological and linked to the famous "biological clock". Others still see motherhood as a way to seal their love with a partner.

In the psychic life of the woman, the desire of child is inscribed in the logic of passage of the body of the young woman to that of the mother. It is very often above all a desire for pregnancy. This "misunderstanding" reveals itself particularly when the pregnant woman has idealized her child during nine months, and discovers a child made of flesh and blood necessarily different from the dream.

Pregnancy leads to psychological and physiological modifications of the whole maternal organism, with a return to normal after the birth [3].

Generally, the modifications are more accentuated during a multiple pregnancy than during a mono-fetal pregnancy. Therefore, it is important to have support and follow-up adapted to each woman and, above all, a good knowledge of all the changes that the woman may face before, during and after her delivery [4].

II. OBSTETRICAL MONITORING SYSTEM

Ideally, a woman contemplating pregnancy should consult with her primary care physician prior to conception; in this way, she can learn more about the risks of pregnancy and how to reduce them [5].

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Routine monitoring of the pregnant woman is necessary to ensure the health of the woman and the fetus.

Under the new WHO model for antenatal care, the number of antenatal visits is being increased from four to eight. Recent evidence indicates that increasing the frequency of prenatal visits in the health system for women and adolescents is associated with a lower likelihood of stillbirths, as these visits provide more opportunities to detect and manage potential problems. Providing 8 visits instead of 4 reduces the perinatal mortality rate to 8 per 1000 births [1].

This new model increases the number of maternal and fetal examinations to detect problems, improves communication between providers and pregnant women, and increases the likelihood of a positive pregnancy outcome. It recommends that an initial visit occur in the first 12 weeks of pregnancy and that subsequent visits be scheduled at 20, 26, 30, 34, 36, 38, and 40 weeks [6].

The first routine prenatal visit should take place between 6 and 8 weeks of pregnancy [7].

Figure 1 presents the schedule of consultations communicated by the French health insurance to be respected for a good progress of the pregnancy.

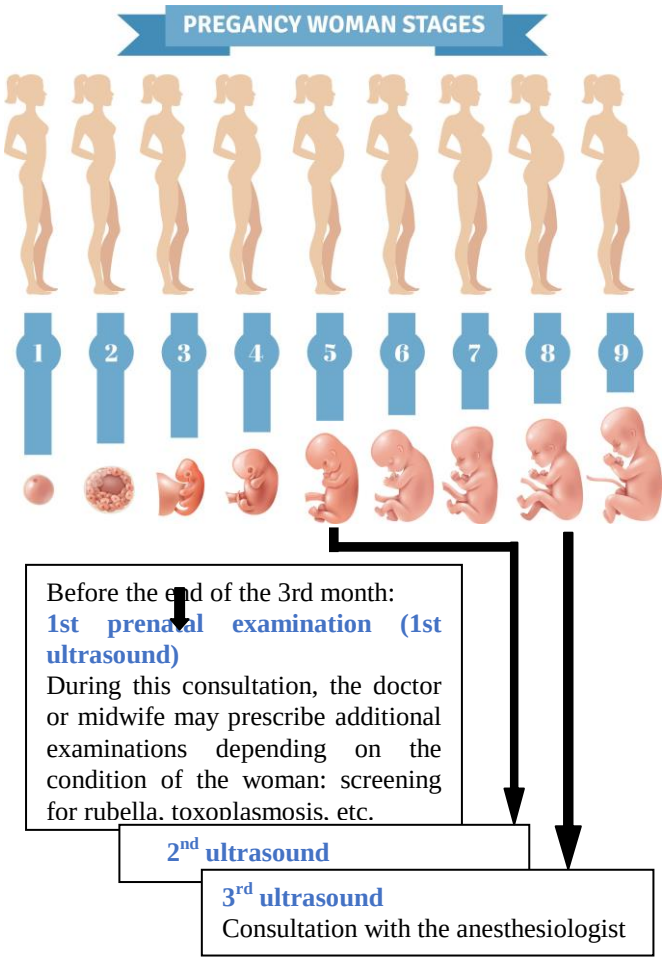

Figure 1 *Pregnancy woman stages*

Prenatal visits may be more frequent if the pregnancy is high risk or less frequent if the risk is very low.

Complications during pregnancy

Risk factors for complications during pregnancy include:

- Pre-existing maternal problems
- Physical and social characteristics (e.g., age)
- Problems in previous pregnancies (e.g., history of preeclampsia)
- Problems that develop during pregnancy
- Problems that develop during labor and delivery

The presence of a pathology during pregnancy can increase the risk of complications [8][9]. It can be a pathology:

- Present before birth (pre-existing conditions)
- Develops during pregnancy but is not directly related to it.
- More likely to occur during pregnancy.

Diabetes and high blood pressure are examples of pre-existing conditions that increase the risk of problems during pregnancy [10].

Pre-eclampsia is estimated to affect more than 7% of pregnancies worldwide.

According to the website of the Association for Prevention and Action against Pre-eclampsia Apape.fr, "eclampsia mortality is the second leading cause of maternal mortality (nearly 11.35% of deaths), behind delivery hemorrhage, which accounts for 36% of maternal deaths".

It is also a major cause of perinatal mortality in children worldwide.

According to the French National Institute of Health and Medical Research, 40,000 French women are affected each year [11].

This common disease of pregnancy, caused by a dysfunction of the placenta, is characterized by high blood pressure and an increase in the amount of protein in the urine. There is no treatment at this time: a pregnant woman with preeclampsia must either undergo a medical termination of pregnancy (MTP) at less than 22 weeks of amenorrhea, or a cesarean section with plans to resuscitate the baby later in the pregnancy. If left untreated, preeclampsia can lead to serious complications and even death for the mother.

These complications include eclampsia, a fatal epilepsy-like seizure, acute renal failure, cerebral hemorrhage, a retroplacental hematoma or HELLP syndrome, which is a severe gravid microangiopathy [12].

The difficulty with this disease is that some of these symptoms are common and do not necessarily indicate preeclampsia. Hence the delay in diagnoses. In 2014, the WHO published 23 recommendations to prevent and treat preeclampsia and eclampsia [13].

It is therefore imperative for each pregnant woman and her entourage to be aware of the risk factors (a history of preeclampsia, a multiple pregnancy, a first pregnancy (nulliparity), chronic hypertension, renal pathology or diabetes, obesity (BMI over 30) being over 40 years old or under 18 years old...) and know the signs that should alert (systolic blood pressure > 140mmHg, diastolic > 90mmHg and protein concentration in urine > 300 mg/24h) [14].

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III. OBSTETRICS IN THE 21ST CENTURY

Currently, women tend towards physiological delivery but in case of complications, this cannot be envisaged.

So, we're talking about a respected birth, the origin of this expression comes from a movement bringing together citizens and professionals of perinatal care in response to the overmedicalization of childbirth that emerged with its hospital follow-up that became widespread after the Second World War [15][16].

To get out of overmedicalization, respect the rights of the parturient and choose the conditions of her delivery.

During the first two thirds of the 19th century, despite better training of health care workers, hospitals were still frightening places that only took in young mothers or poor women. Births there are much more dangerous than at home, at the Maternity of Port-Royal, 31 of the 32 births die.

From 1878, a decisive step was taken when Pasteur showed doctors the vital importance of rigorous aseptic, antiseptic and sterilization practices. If implemented, they can dramatically reduce maternal mortality. Gradually, the hospital stops being scary and appears as a sanitized place, where medicine is practiced that saves and heals.

From the 1840s, medicine discovered the power of anesthetic and analgesic “drugs” (opium, morphine, chloroform, ether). While these findings primarily change the conditions under which surgery is performed by making anesthesia possible, they can also be applied to deliveries.

In the early twentieth century, procreation depended on sex (and vice versa), fertility control was uncertain, infertility was unattainable, and the risk of death at birth was high. By the end of the twentieth century, sexuality and reproduction could be separated, fertility appeared as a choice, sterility no longer prevented births, and the threat of death was almost entirely ruled out. This is a radical social, cultural, and family transformation.

The Health System Technological Process, the ideology of progress and the mastery of "nature" impose values that emphasize scientific knowledge.

Pregnancy and childbirth techniques are becoming increasingly complex and sophisticated, even in the case of physiological pregnancy.

Particularly favorable social conditions explain the beginning of medicalization in the 20th century, and it is during the second half of the century that the power of the medical profession is imposed on all, with the systematic practice of examinations of all kinds and the development of ultrasound.

Inspired by the phobia of microbes and Pasteur’s legacy, doctors impose hygiene rules to the detriment of the wishes and modesty of women who are stripped, shaved, forced to wear a white hospital gown, and who undergo intestinal enema and vaginal touching at regular intervals. They give birth immobilized, lying on their backs, feet in stirrups, legs in the air and separated.

The baby is most often removed, cared for, and treated by the care team, and then brought to the mother every three hours, regardless of whether he cries before or not, for a 15-minute feeding. At home and in the home of birth, women have the freedom to move as they see fit [17][18][19].

In the 1920s-30s in France, childbirth in a medical environment was widespread, especially in the big cities; in Paris, in 1939, it already affected most births (67.8%, against 7.7% at home and 24.3% in a midwife). Women accept this change for a variety of reasons. First, because the State has been more helpful to them at the time of their childbirth since it has become aware of the dangers of a low birth rate. Indeed, France is becoming dangerously depopulated: the birth rate is falling steadily, and the absolute number of deaths exceeds that of births from 1935. To boost birth rates, the State must help the lowest paid workers for their childbirth: they are entitled to a lump sum payment for childbirth expenses, to the payment of an allowance equal to half the salary for twelve weeks and to monthly nursing allowances. Although in 1939 the law was still poorly implemented (only one third of births gave rise to benefits), it made childbirth a medical act, not an act of mutual assistance or assistance, as it had been in the past. This is gradually making it easier for mothers-to-be to have their diapers in a medical space.

At the same time, the hospital has changed to become a center for medical technology. In addition to maternity and specialist consultations, there are testing laboratories, a milk donor center, a prenuptial consultation, an antisyphilitic dispensary and a maternity center specially isolated for tuberculosis parturient.

At the end of the Second World War, births at home disappeared almost completely, even though there were always a few "outcasts" who chose to give birth at home, until the 1970s. This "disappearance" appears not only as a triumph of the medicalization of childbirth, but also as its approval favored by women and the population in general.

This analysis, which is at the very least reductive of reality, remains dominant until the beginning of the 21st century and constitutes the reading grid used to justify the systematization of prenatal diagnosis, epidural diagnosis, the unreserved increase in the rate of cesarean section initiation and other generalized practices despite numerous international recommendations to the contrary." Perinatal care is a political concern. Since the 1970s, funds have been allocated to the obstetrics sector to equip maternity hospitals with state-of-the-art technology and ultrasound equipment, thus gaining a central position in public health issues [20].

In this sense, the general objective of public health policies is to prevent, not only to prevent the onset of diseases, but more broadly to anticipate foreseeable pathological events. Physicians must treat the pathology, but also prevent it from occurring. These two risk logics are articulated and intertwined in an unstable situation. It is possible to move quickly from prevention and simple surveillance to emergency. So, obstetricians become risk managers.

Part of the reason for this homogeneous thinking is the Medical Training received.

The feeling of insecurity is pervasive and is therefore based on the idea of the need to focus on pathology research, rather than on monitoring a physiological process.

Despite obvious improvements in safety and comfort, the hospital has long maintained a negative image: women who

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can afford it still prefer to give birth at home, even in large cities.

The evolution that led women to leave their homes to give birth in a medicalized environment lasted several centuries and had very varied causes: the new interest of doctors in obstetrics and their entry into birth chambers; the desire of women to no longer die in childbirth and to no longer suffer; the changes in medical theories after Pasteur and the transformation of hospitals into high-tech institutions; the medicalization of society and especially of birth and early childhood [21].

Although women have not always been the cause of these changes, they have not been the victims of this evolution; the most conscious have wished for these changes, which meant, for them and their babies, more security, less suffering, and mutilation [22].

But the place where a woman gives birth and where her child is born is much more than just a place of care. It participates in the symbolism and mystery that are at the heart of every human birth. It conditions several gestures, attitudes, and different forms of sociability. When the woman who gave birth was accompanied and reassured in her work and her pain by the women of her community; this carnal and moral help was crucial, it enabled us to overcome the anguish of death that inevitably surrounds each coming into the world[23].

IV. PROBLEM: DEFINITION, METHODOLOGY AND FINDINGS

A. Analysis and Results

Our study is based on observation and experience, it is an empirical study, for which a questionnaire has been created and is shared with women who have experienced pregnancy or still pregnant.

The questionnaire is composed of 3 categories (Before, during and after pregnancy) for a total of 11 questions.

The study was carried out with different ethnic groups, their origins were not a criterion that we wanted to work on since our main objective is to be able to improve the follow-up of pregnant women, but in view of the results, they show a significant difference not only from the healthcare system but also from culture, sensitivity to pain and desires that vary from one woman to another.

Figure 2 presents the percentage of women whose responses were analyzed in this research according to their origin.

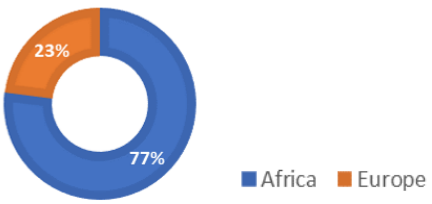

Figure 2 *Geographical distribution of women in the study*

Table 1 lists all the questions asked.

1. Are you aware of the risks you may face during pregnancy?
2. From when are you followed by a midwife or gynecologist? Before conception, during pregnancy?
3. Do you feel adequately accompanied?
4. Have you had any risk education before, during and after childbirth?
5. Do you often go to the emergency room at the first sign of trouble?
6. Can you call your midwife or gynecologist at any time?
7. Do you take the time at the midwife to speak up and ask all your questions?
8. After you leave the maternity ward, are you being followed to get back into shape even if you haven't had surgery?
9. During your stay, are you satisfied with the maternity support during and after childbirth?
10. If you experienced a pregnancy during the COVID crisis, can you tell us about your experience? Were you satisfied with the follow-up and support you received?
11. Do you have other things to trace that can be used to simplify medical accompaniment and follow-up?

Table 1 *List of questions whose answers form the basis of this study*

In the rest of this analysis, we will talk about Africa and Europe to simplify the comparison. The results of this analysis are limited to the women interviewed and in no case can it be generalized to all African and European women.

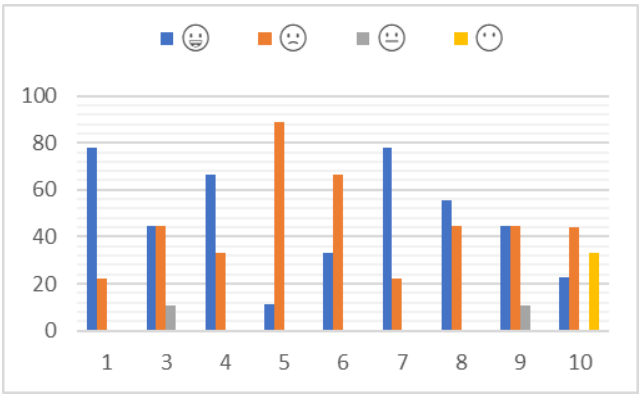

Figure 3 *Results of the answers to questions 1,3,4,5,6,7,8,9 and 10 of the questionnaire- Africa*

From Figure 3, we note that Africa has three major weaknesses: the first is the lack of knowledge about pregnancy complications, either because there was never a need to know or to avoid worrying pregnant women or those planning to become pregnant.

The second point is the unavailability of the health professional at any time, but this may be justified by the fact that the gynecologist is not available 24 hours a day, but the idea is to have a replacement in case of need.

The third and last point is the lack of follow-up after leaving the maternity ward, perhaps because the parturient tends to forget herself to take care of her baby full time.

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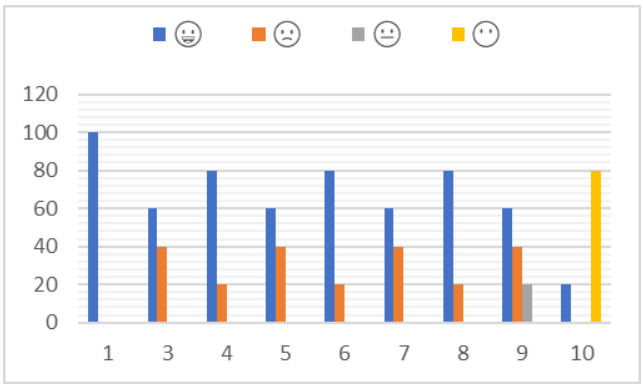


Figure 4 *Results of the answers to questions 1,3,4,5,6,7,8,9 and 10 of the questionnaire – Europe*

When the two graphs are superimposed (Figure 3 and 4), it becomes apparent that the two ethnic groups have common weaknesses, and this mainly concerns the feeling of being accompanied.

Comparing the two graphs in Figure 5, we note that in Africa, there are 11% of women who consult at 6 months of pregnancy, 22% at 3 months compared to 0% in Europe.

This may result in a different level of awareness of the risks associated with pregnancy, the requirement for quarterly medical consultations except in the case where the woman has made a denial of pregnancy, but this case is not present in our study and the need to be accompanied to be reassured about the smooth running of this adventure.

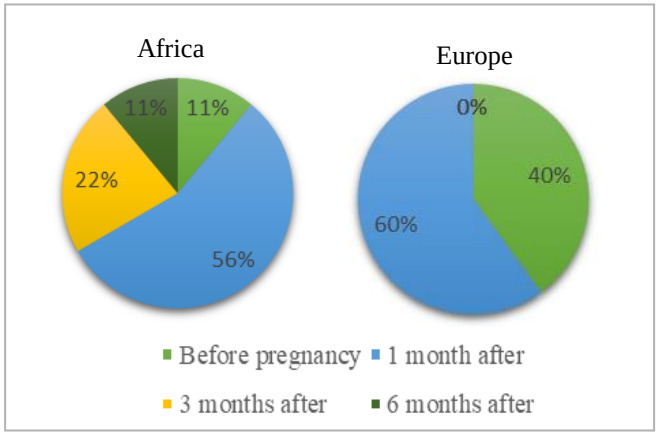


Figure 5 *Percentage of 1st medical consultation (Question 2 of the questionnaire) between Africa and Europe*

Apart from the difference of origin, the last question was to collect proposals for improving monitoring, among those proposals that could be identified by at least 30% of women:

- Explain everything to the pregnant woman
- Nutrition Tips
- Medical support before pregnancy
- At the time of delivery, the medical or paramedical team must respect the feelings and concerns of the parturient and respect the fears of childbirth and its dangers
- A gynecologist must be present at the time of delivery
- Awareness sessions that both parents can attend without exception to learn how to manage pregnancy, childbirth and why not behavior with the newborn

To consider the proposals mentioned above and improve the follow-up of the pregnant woman, we will model her prenatal journey.

B. BMPN 2.0 Collaboration Diagram

For this modeling, we chose the collaboration diagram for analyzes, process sequence flow and message exchange between participants.

Figure 6 shows that the patient interacts with 3 entities: her gynecologist, the emergency room, and the medical laboratory.

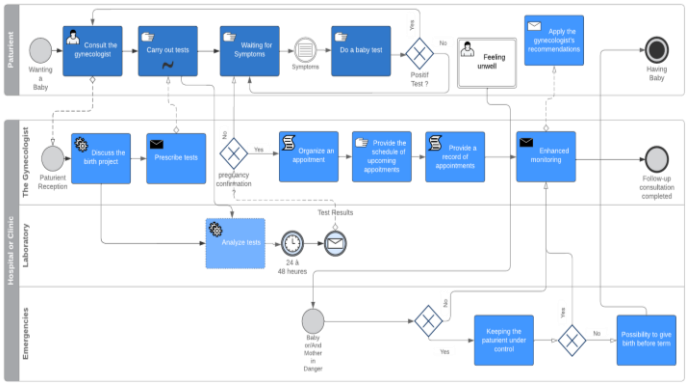


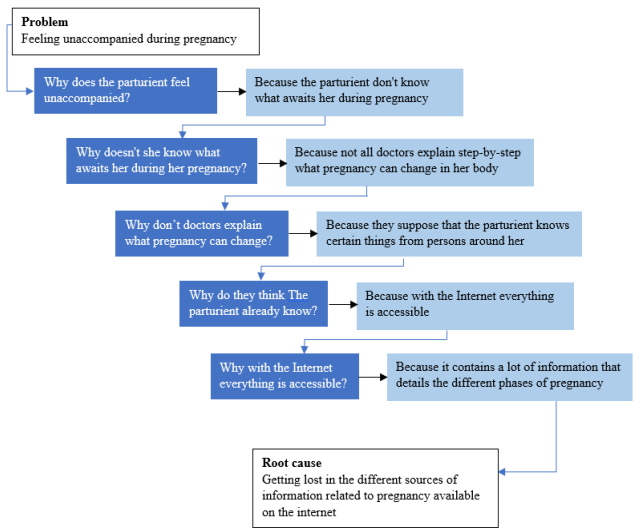
Figure 6 *Obstetric Follow-up Collaboration Diagram*

Use of emergency services is usually carried out in the event of the gynecologist's unavailability or even out of work schedule or in the event of symptoms considered serious and requires a medical opinion quickly.

C. Lean Six Sigma

As we could see before, pregnancy generates a lot of follow-ups and a good knowledge of what happens in the woman's body for 9 months. Between consultations, blood tests, and sometimes visits to emergency rooms, the woman ultimately feels morally and physically exhausted.

The idea is to make this adventure more enjoyable and involve the woman more in the medical decision-making if



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necessary. So, it will be necessary to act not on the level of medical processes directly but rather on the quality of the information that the woman receives either from her doctor or elsewhere [24].

This does not mean that women should not consult their doctor anymore, but they should avoid consulting their doctor because the baby does not move often in the 8th month.

For this the application of method 5 Why, which is one of the Lean Six Sigma tools, allows root cause identification to be consulted more frequently in case of doubt. By repeatedly asking the question "Why?" to the problem, layers of symptoms that lead to root causes are removed one at a time.

Figure 7 shows that the root cause of women's feeling of not being accompanied during pregnancy is getting lost in the different sources of information related to pregnancy available on the internet.

Figure 7 *5 Why method*

To solve this problem, we propose a numerical solution explained in paragraph V.

D. Simulation

In this simulation, we will focus on the part of pregnancy complication where there is a decision to be made by the doctor in agreement with the parturient.

Figure 8 presents the collaboration diagram for pregnancy complications.

The simulation was performed by Enterprise Architect software Version 16.1.

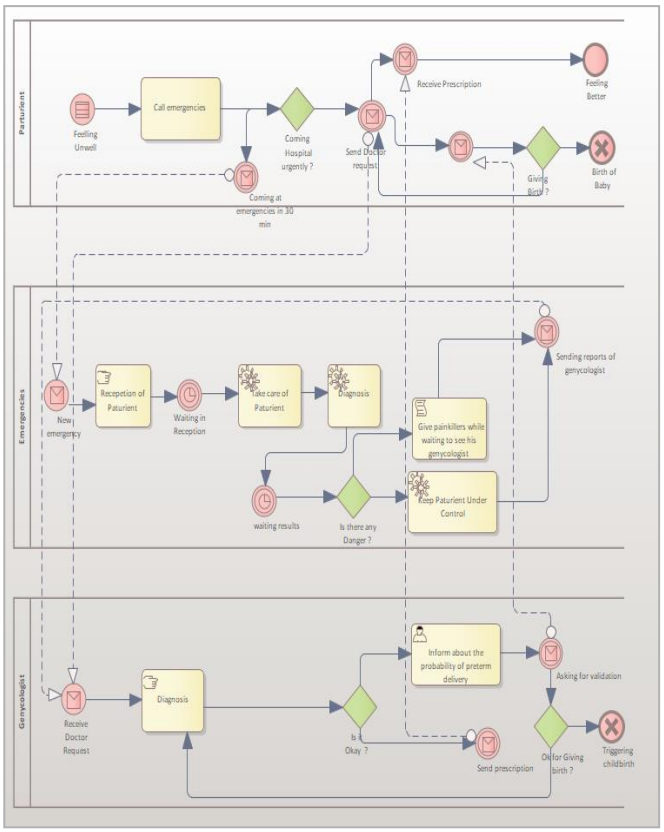

Figure 8 *Collaboration Diagram BPMN 2.0*

We will take an integer n, initialized to 1 (one hour) at the beginning and which will be modified by the activities by adding constant values. The branches of the exclusive gateways will be conditions according to whether n is greater than or equal to or strictly less than a given value.

To visualize the path followed and the activities crossed, we initialize the simulator with a control of type TriggerCount which allows to define the number of times that the object or the connector must be treated during the simulation.

The objective is to know the estimated time until the birth of the baby.

After running this model, we find that the minimum duration (the case that requires emergency delivery) is estimated to be over 108 hours, from the onset of symptoms to the emergency delivery. This duration remains an estimate that can be shortened or extended depending on the constraints taken into account.

This information can be shared with women in order to prepare them mentally for the time they can spend in a medicalized environment in the event of a pregnancy complication, hence the value of following WHO recommendations that reduce the risk of complications.

V. DISCUSSION

This work is based not only on theoretical data but also on data collected from women who have experienced pregnancy.

The objective is to go further in this study and find a communication and monitoring system accessible to everyone regardless of their social situation (free service).

France has taken this step by creating a digital health space "Mon espace santé" available since January 2022, intended to simplify the journey of users and exchanges with health professionals for better care.

The desired system, based on artificial intelligence, will monitor the progress of pregnancy by entering parameters.

Figure 9 shows the steps taken to process the parturient request. As soon as pregnancy is diagnosed, this system will initially be fed by the data entered by the health professional during the visits, it will be a digital and reactive health record ①.

After the system generates the calendar of mandatory appointments and the WHO recommendations to follow, this will prevent it from being lost with all the information published on the internet, the parturient receives a notification to warn her ②.

In case of concern, the parturient can send a description (audio or in writing) of her condition ③ and then she will have a quick response of what to do (either consult urgently or get in touch with her gynecologist or propose a treatment to calm for example pain, if possible, in her case) ④.

This system will have a database with all the information necessary to follow up on the parturient, so it will process the request based on her medical record.

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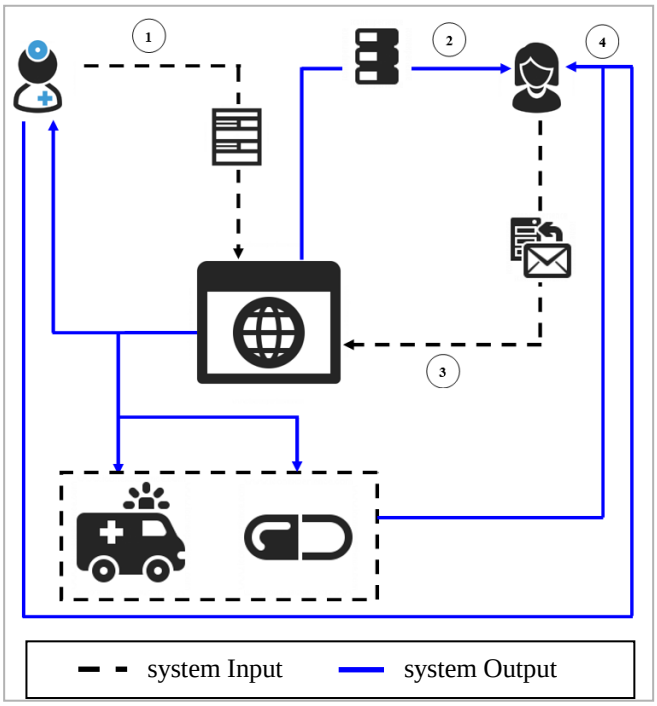

Figure 9 *Digital pregnancy tracking system*

CONCLUSION

Artificial intelligence is becoming increasingly important in the medical sector.

Several projects based on artificial intelligence are being launched to satisfy couples with a desire for a child [25][26][27].

The Bernabeu Institution, a world reference institution in reproductive medicine, is one of the entities that is carrying out some of its projects regarding the identification of factors that increase the risk of biochemical miscarriage after the transfer of chromosomally normal (euploid) embryos in PGT-A cycles and the prediction and identification of the embryo with the greatest potential for implantation [28].

Before the "Pregnancy" project is realized, the objective of this work is to improve the monitoring and support to know the status of the pregnancy at the moment. This system will allow the future parents to know the different changes they can have. This tool will also be a means of communication between the doctor and the parturient in case of emergency. But before, the parturient can enter her symptoms on the system and look at the recommendations to follow according to her condition without being drowned on the internet in a lot of information that can lead her to a wrong direction that could lead to the loss of her baby. This system will never replace the intervention of a professional, but it will help to position oneself if necessary. During the COVID 19 crisis, prenatal and postnatal preparation classes were cancelled in hospitals and obstetrical appointments were reduced, causing frustration and anxiety for the parturient [29].

Being reassured throughout her pregnancy, the woman will be fulfilled and will transmit good vibes to her baby [30].

Lean Six sigma is used in this study to optimize the monitoring and support pathway, make it easier and more accessible and especially more useful for pregnant women. Women at the end of pregnancy find it difficult to move around, avoiding the round trips for examinations and analyses could be a great relief but keeping the essential to monitor the health status of the woman and the baby.

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