Smart Anamnesis for Gyn-Obs: Issues and Opportunities

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Abstract. Completeness and accuracy of data is probably a persistent and intrusive problem in any process related to data capture. This is especially true in the clinical field, where omitting significant information can have considerable implications for diagnosis and treatment in general. History taking from patients represents a crucial phase for physicians in order to evaluate the patient's wellness status and to perform correct diagnoses. As a routine procedure, it is a time-consuming and not so appealing obligation. In this paper we present a smart approach to anamnesis in order to gain as much data as possible and to have high quality information by avoiding any misunderstandings or errors. The approach is mainly based on the possibility to capture data directly at the source increasing the overall effectiveness of physician's time and of the visit itself. Its feasibility has been evaluated in the context of a complex clinical domain: maternal and fetal assessment during pregnancy.

Keywords: Medical history taking · Data incompleteness · Data quality · Data capture · Maternal and fetal assessment

1 Introduction and Background

The medical history taking is the most common task performed by physicians. That is why Engel and Morgan defined it "the most powerful, sensitive and versatile instrument available to the physician" [1].

Scientific discoveries and technological innovations have deeply changed the way to perform diagnoses and to treat diseases. But neither scientific nor technological advances in medicine have changed the fact that a "good" history taking contributes significantly to problem detection, diagnostic accuracy and patient health outcomes. By the medical history, physicians acquire 60–80% of the information that is relevant for a diagnosis [2] and the history alone can lead to the final diagnosis in 76% [3].

History taking and communication skills programs have become cornerstones in medical education over the past 30 years and are implemented in most US, Canadian, German and UK medical schools [4]. However, history taking cannot be represented by specific and universal rules since it is highly contextual, depending on situation, patient and physician, cultural characteristics and other similar factors.

The medical history does not involve only the current situation of the patient. Very important are similarly the past medical history, the drug history, the family history (in

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order to find out if there are any genetic conditions within the family) and the social history, including all the patient's background: smoking, alcohol, habits, etc.

Having access to all these information is not a trivial task.

Physicians need to remember many questions relating to the management of each condition and omitting an important question can actually compromise the diagnosis. For example, studies show that 50% of psychosocial and psychiatric problems are missed during medical consultations [5] and that 54% of patient problems and 45% of patient concerns are neither elicited by the clinician nor disclosed by the patient [6].

Computer-assisted history taking systems (CAHTS in the following) are tools that aim to aid physicians in gathering data from patients to inform a diagnosis, a treatment plan or both [7].

Although CAHTS were first described in the 1960s [8], there is still uncertainty about the impact of these methods on medical history data collection, clinical care and patient outcomes, hence they often remain underused in routine clinical practice [9].

Bowling in [10] describes that the various CAHTS typologies depend on three interrelated factors:

- the information technology used to collect the information (e.g. personal computer, personal digital assistant, Internet, telephone, etc.);
- the administration mode (e.g. administered by an interviewer or self-administered);
- the presentation channel (e.g. auditory, oral or visual).

The author presented the different and serious effects that the administration mode for example can have on data quality. Indeed, a very important aspect to take into account when dealing with the medical history taking, is represented by the social desirability bias [11]: a factor defined as the effect of disturbance that comes into play when the patient, responding to an interview, has a chance to give answers which may be deemed to be "more socially acceptable" than others in order to look more "normal" as possible.

If patients use an electronic device for a CAHTS, they are less likely to falsify data when compared with those using pen-and-paper, as demonstrated by 4 randomized controlled trials [12–15].

In particular, self-administered computer-assisted interviewing is perceived favorably by patients because computer systems cannot be judgmental towards sensitive behavioral data. Therefore, CAHTS are particularly useful in eliciting potentially sensitive information (e.g. alcohol consumption, psychiatric care, sexual health and gynecological health).

In this paper we discuss the issues and opportunities for the adoption of a smart approach to anamnesis in the context of maternal health and wellbeing as well as fetal growth monitoring. The approach is in line with the current evolution of smart hospitals for smart cities and it is mainly based on the possibility to to gain as much data as possible directly at the source in order to have high quality information and to increase the overall effectiveness of physician's time and of the visit itself.

2 Motivation

Perinatal period is a very delicate stage of life for both mother and families. Maternal and fetal constant monitoring during the whole pregnancy is a critical aspect since it may detect early alarm signals for a wide range of pathologies in order to promptly treat potential complications and to avoid unnecessary obstetric interventions at the time of delivery.

Physicians refer to standard reference charts to evaluate the fetal growth development but such reference values are characterized by a series of limitations making difficult to use them as a standard for diagnoses, such as data obsolescence, methods heterogeneity, lack of data, hospital-based samples, exclusion criteria, missing of several important factors to take into account (lifestyle, familial aspects, physiological and pathological variables, etc.) that may lead to inaccurate diagnoses of fetuses as small (SGA) or large (LGA) for gestational age.

The lack of data is the major limitation. Considering that every year in the world there are about 160 millions of newborns, the huge amount of data potentially involved in the analysis of fetal growth and maternal wellness should provide a comprehensive analysis able to avoid false-positives and false-negatives diagnoses and to prevent undue anxiety in families which typically leads to unnecessary and expensive further investigation.

Unfortunately, a global strategy which addresses the lack of data issue does not exist. Data are still missing and this can be due to several reasons which are not only of technical nature [16]:

- the local nature of traditional data collections, managed by bureaucratic units;
- the legitimate conflict of interest among physicians (practicing defensive medicine), patients (interested in health protection) and Health Administrations (focused on cost reduction);
- the lack of adoption of proper data harvesting strategies and techniques.

Defining new approaches to data collection in order to analyze, visualize and share information that could be useful in decision-making processes and hence to take advantage from the big amount of accumulating clinical data in order to extract useful knowledge and understand patterns and trends within the data.

Mothers and families are very sensitive to all aspects concerning the fetal wellbeing and are hence highly motivated to change their lifestyle and their approach to healthcare. This means that, although physicians may be reluctant to use electronic devices for data gathering that could require extra time, patients have a clear and valid reason to spend additional time to address their own problems and so there is no need to educate them on how the adoption of a new approach to data collection would improve the entire system.

3 Our Approach

In the era of Internet of Things (IoT), smart devices can help to transform clinical practice and hence to improve the delivery of care. As specified in [17], in order to collect data from all possible sources directly from the field, new data harvesting techniques can be adopted:

1. form-based input on Web pages and mobile App;
2. new generation mobile devices, which typically are packed with sensors (e.g. GPS, gyroscopes, accelerometers, touch-sensitive surfaces, microphones and cameras) or have physical interfaces that allow the connection of external modules (e.g. blood pressure cuffs, blood glucose monitoring) or wearable sensors (e.g. heartbeat and contraction monitoring) linked to smartphone to harvest and monitor data;
3. direct connection to medical equipment (e.g. medical imaging machines, medical ventilators, medical monitors, etc.) with automatic DICOM metadata decoding and/or signal processing techniques;
4. automatic data extraction from medical documents, both printed and digital, provided to patients after medical test or extracted from large digital archives;
5. data-scraping techniques able to emulate a human agent interacting with the user interface of a non-interoperable software in order to insert/extract relevant data from electronic documents (web pages, electronic forms, etc.), for specific purposes or for massive ingestion;
6. smart digital devices (e.g. for weight and height measurement, speech-to-text software, etc.) provided to physicians to simplify data collection at the clinic visit.

For sake of simplicity, in the rest of the paper we will refer to these techniques with the name of channels.

In the gynecological and obstetrical sector, channel 1 (form-based input adoption) is more appropriate for patients which in general have a strong motivation to spend their time to describe in detail and to precisely address their own problems. This is a time-intensive channel and for this reason it is rarely adopted by physicians. Furthermore, physicians do not trust very much the ways their patients may collect data via electronic devices since patients' participation can cause an overflow of irrelevant or trivial information, due to the fact that patients are typically unable to assign to data the appropriate significance (i.e. its medical meaning). Physicians typically handle medical information on paper and hence avail themselves of collaboration of clinicians to transcribe handwritten worksheets.

Channel 1 has been deeply exploited as a sort of "self-reported interview pre-visit": the patient fills out a questionnaire a few days before the visit by using a personal computer, a smartphone or a tablet.

Such questionnaire is composed by two main parts: a profile section which includes:

- personal data (e.g. name, date and place of birth, age, maternal and paternal ethnicity, place of residence, educational background, job, contact information like email and phone, etc.);

- medical data (e.g. potential pathologies and infections which can be developed during pregnancy, before pregnancy or can be due to genetic conditions within the family);
- biometric data (e.g. weight, height, etc.);
- lifestyle data (smoking, nutrition, physical activity, alcohol consumption, hobby, allergies, intolerances, etc.). A screenshot of the profile section is showed in Fig. 1.

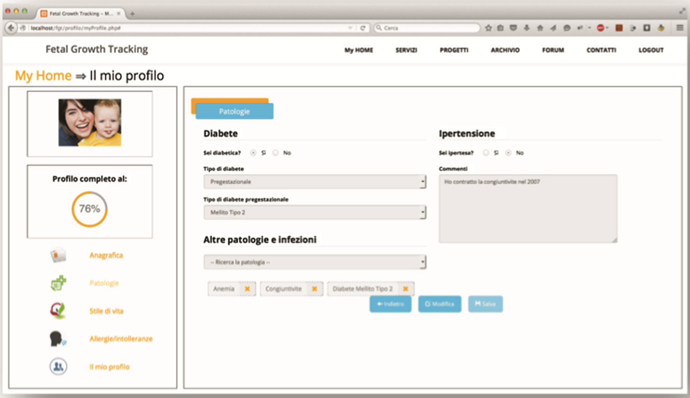

Fig. 1. Web-based questionnaire filled out by patients before visits

The second part of the questionnaire includes the actual anamnesis:

- menstrual history: the first important historical information that obstetricians usually gather is the Last Menstrual Period (LMP). Beyond the date of the first day of the LMP, patient has to insert cycle length in days and normality. Information on prior contraception and fertility treatment are also important to add in order to determine the utility of the LMP to predict the Estimated Date of Delivery (EDD);
- obstetric history: past pregnancy history is an important predictor of pregnancy risk in multiparous women. Patients has to indicate the dates of deliveries, types of deliveries (vaginal or cesarean), indication and type of uterine incision if a cesarean delivery was performed, birth weight and gestational age of previous infants, complications of previous pregnancies, and current state of health of previous children;
- psychosocial evaluation: a description of the workplace and the woman's job responsibilities should be elicited to rule out any significant exposure to toxins or ergonomic stressors that could have a negative impact on the pregnancy. Pre-existent problems of anxiety and hypertension should be also elicited;
- medical and surgical history: patients are asked specifically about common medical conditions as well as uncommon conditions that are known to have serious effects on pregnancy. Common problems include for example diabetes, chronic hypertension, asthma, cardiac diseases, etc. Less common but equally important issues include lupus, thyroid disorders, chronic hepatitis, tuberculosis, bleeding disorders, chronic

renal disease, cancer, etc. A surgical history with emphasis on abdominal procedures or orthopedic procedures involving the pelvis is also taken into consideration.

Once filled out, the questionnaire is available for consultancy to the Secretariat of the hospital or of the medical office in order to create the patient report. This interface allows to suggest in real-time to physicians which part of the anamnesis has to be completed and which values are "borderline". The quality of inserted data is guaranteed by means of data validation checks. In this way, gathering such data does not need to add to physicians' time and, in principle, permits more time for the patient to discuss their actual health problem rather than routine aspects of medical history with physicians.

Channel 2 (new generation mobile devices adoption) is based on the possibility to exploits the benefits that can be achieved by adopting wearable sensing devices for health monitoring which allow to sync data with the smartphone. New generation mobile devices are typically packed with sensors which allow to harvest data. There are many devices already on the market for fitness and wellness that use consumer-facing applications which can be easily incorporated into clinical practice in order to help both patients and physicians monitor vital signs and symptom.

During the third trimester of pregnancy, mothers can wear on the belly a small and flexible device in order to continuously monitor the baby kicks by uploading automatically the information to smartphones. Other kinds of sensors can allow to detect and record the baby's heartbeat and to measure the frequency and duration of contractions in order to provide an early indication of baby's and mother's health.

The direct involvement of mothers allows to constantly monitor their baby's fetal activities and alert their caregivers when something seems out of the norm.

In case of high-risks pregnancy, this channel allows to provide physicians an observation over time of heart rate variations in order to develop a sort of heartbeat history during pregnancy.

Channels 3, 4, 5 and 6 allow a direct and automatic data transfer eliminating hence the need for human entry. Direct data capture improves data ingestion and reduces potential sources of errors leading hence to a greater accuracy.

Channel 3 (direct connection to medical equipment) allows data collection directly at the source, i.e. at the output of the medical equipment used for the assessment of fetal biometric parameters, such as the traditional Ultrasound machine. In this case, the adopted standard for the distribution and viewing of medical images is the DICOM (Digital Imaging and Communications in Medicine) standard, which allows obtaining discrete values directly from its headers.

The direct connection with the ultrasound machine allows to gather data (acquired pictures and biometric measures) during the visit and to manage and integrate them in the patient history at the time of visit with no need for human entry.

In our case, channel 4 (automatic data extraction from medical documents) is based on the adoption of the Optical Character Recognition (OCR) technique, which allows to analyze and extract textual data typically included in the ultrasound pictures which are usually accompanied by measures (biometric parameters with the corresponding values), derived data (gestational age measured in weeks and days) and other info (ultrasound machine model, exam date, etc.).

This channel is used in strict connection with the previous one, since it allows to automatically assemble several parameters starting from the pictures acquired by the ultrasound machine and stored into the central system.

Channel 5 (data-scraping techniques adoption) is mainly based on software techniques able to emulate a human agent interacting with the user interface of a non-interoperable software in order to insert/extract relevant data for specific purposes or for massive ingestion.

This channel is very helpful in the starting stage, when a first data ingestion and data integration process is needed. Physicians have information about several patients on the personal computer in their office. Such channel allows to retrieve all data directly from web pages or electronic forms with no need for human entry.

Channel 6 (smart digital devices adoption) is in line with the current evolution of Internet of Things in which smart devices can help to transform clinical practice and to improve the delivery of care as in the "connected health".

Medical offices can be transformed into "smart rooms" which simplifies and enriches the collection of patients' data.

The maternal weight gain monitoring during pregnancy is a critical matter the health of pregnancy and for the maternal and fetal long-term health. It depends on several factors such as the woman's weight before pregnancy, the woman's height, the type of pregnancy (one baby or twins), etc.

A precise and continuous monitoring can serve to evaluate whether patients are gaining less than the recommended amount of weight (this is associated with delivering a baby who is too small, with consequences like difficulty starting breastfeeding, increased risk for illness, etc.) or if they are gaining more than the recommended amount of weight (this is associated with having a baby who will born too large, which can lead to delivery complications, cesarean delivery, obesity during childhood, etc.).

Medical offices can be equipped with smart and low-cost instruments which can allow to obtain and automatically store precise measures during visits.

A WiFi scale, using the 802.11g wireless standard, is able to transmit and store data relating to the weight, fat mass, lean mass and body mass index (BMI) of patients who stand on the scale itself. Such measures are automatically taken before the visit starts in order to collect them and to analyze the variation over time. The same is true for measuring height: a digital stadiometer is able to quickly, easily, and accurately measure the height of patients.

In Fig. 2 the overall architecture of the proposed approach is presented. It can be divided into two main parts:

- the patient area, which includes all the possible devices (PC, notebook, tablet and smartphone) that a mother can adopt to perform the web-based questionnaire and to follow her own visits and monitoring reports;
- the medical office area, which includes all the possible devices (ultrasound machine, PC, scale and stadiometer) that physicians can exploit to capture data directly at the source and to store data on a centralized server.

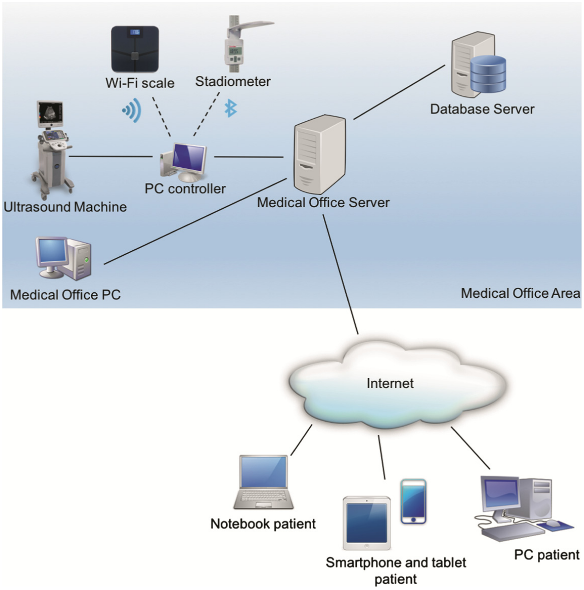

Fig. 2. Architecture of the proposed approach

4 Conclusions

The benefits coming from the combined adoption of the six above-mentioned channels in order to gather as much data as possible before, during and after each gynecological/obstetrical visit are manifold: it saves physicians' time; it improves delivery of care to patients having special needs; it facilitates and expand the data collection, especially in case of potentially sensitive information (e.g. sexual history, alcohol consumption, etc.); it allows an easier availability and access to medical information for both patients and physicians and can also facilitate patients check their own data.

On the other hand, the extensive adoption of these methods in real medical settings is hindered by the lack of technical experience which frustrates both patients and physicians leading them to the preference for pen-and-paper methods; current regulations related on privacy and confidentiality and strong defensive medicine reasons.

The different channels have been tested separately in the context of two different projects: one carried out in collaboration with the the Operative Unit of Clinical Pathology of the main hospital of Lecce, in Italy, dealing with the possibility to exploits data-scraping techniques able to insert/extract massive amount of data from electronic documents in order to reduce the occurrence of inappropriate exams requests [18] and another one in collaboration with the Department of Gynecology and Obstetrics of the main hospital of Lecce, in Italy, dealing with the possibility to create dynamic and personalized fetal growth curves more appropriate for diagnostic purposes, by exploiting OCR techniques for massive data ingestion [19]. Channels have been subsequently adapted to the specific features of gynecological and obstetrical studies. As future work, we plan to perform the integration of the different technologies in a real case.

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