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# IoT Enabled Ante Natal Check-Up in Rustic Environment

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*Abstract-- The rapidly growing use of internet has given new insights in medical practices and clinical studies. Patient's interactions with doctors were limited to visits, and telephone and text communications special in rural areas. Pregnancy is most important event of mother's life & normally results positive in case of child births but in some cases it is life threatening for mother & child due to lack of proper common check-ups, investigations & examination in such period of time specifically in rustic environments like "salt workers living in desert of kutch & fisheries labor living in coastal areas of kutch". There was no method medical staff could monitor pregnant women's health continuously and make recommendations accordingly using ubiquitous & mobile health monitoring equipment's. Internet of things provided approaches to, collect, manipulate, manage, analyze, predict and suggest structured and unstructured data gathered by medical staff using mobile health devices & applications for betterment of patients (mother's) health in critical rustic areas.*

*Keywords-- IoT, Health, ANC, Medical Science, Telemedicine, Data Analytics, Mobile Health (mHealth)*

## I. Introduction

Astonishing progresses in the domain of medical science and technology that our generation uses in the recent years have been possible, predominantly due to the amalgamation of medical science and technology. But when it comes to pregnancy and childbirth are normal events in the life of a woman. Though most pregnancies result in normal birth, it is estimated that about 15% may develop complications, which cannot be predicted. Some of these may be life threatening for the mother and/or her baby. Every minute, at least one woman dies from complications related to pregnancy or childbirth. And for every woman who dies in childbirth, approximately 20 more suffer injury, infection, or disease—nearly 10 million each year <sup>[1]</sup>. Ministry of health & family welfare has many programs for pregnant women & they offer free medical services, tests, medicines & care provided at primary health centers (PHCs) & dispensaries situated in remote villages & even at pregnant mother's residence. Integrating IoT with process of ante natal check-up provides promising possibilities to reduce infant mortality rates (IMR). Using IoT enabled devices doctors & auxiliary nurse midwife can monitor the vitals of mothers, raise appropriate alerts when necessary, and serve as a repository of information on pregnancy <sup>[2]</sup>.

**Internet of Things (IoT)** is a system of reticulated digital devices, electromechanical machines, objects, living organism that are provided with unique identifiers (UIDs) and the ability to transmit data over a network without requiring human-to-human or human-to-computer interaction. IoT is coalescence of multiple technologies, real-time analytics, machine

learning, commodity sensors, and embedded systems. Traditional fields of embedded systems, wireless sensor networks, control systems, automation and others all contribute to enabling the Internet of things.

**Anti Natal Check-up (ANC)** is systemic supervision of women during pregnancy to monitor the progress of foetal growth and to ascertain the well-being of the mother and the foetus. A proper antenatal check-up provides necessary care to the mother and helps identify any complications of pregnancy such as anaemia, pre-eclampsia and hypertension etc. In the mother and slow/inadequate growth of the foetus. Antenatal care allows for the timely management of complications through referral to an appropriate facility for further treatment. It also provides opportunity to prepare a birth plan and identify the facility for delivery and referral in case of complications <sup>[3]</sup>.

## II. Investigation & Information Gathering

ANC supervision can be conducted several times during pregnancy ideally monthly, half monthly & weekly based on timeline of pregnancy & different set of data would be gathered by medical officer, auxiliary nurse midwife, accredited social health activist (ASHA) worker & multi-purpose worker (female) to track mother’s health during pregnancy period. Table 2.1 contains components of ANC <sup>[4]</sup>.

History Taking	Physical Examination	Laboratory Investigations
<ol style="list-style-type: none"> <li>1. Pregnancy confirmation</li> <li>2. Records of previous pregnancy</li> <li>3. Previous medical/surgical or obstetric condition</li> <li>4. Menstrual history to calculate the expected date of delivery</li> <li>5. Nausea and vomiting / Heartburn / Constipation / Increased frequency of urination</li> </ol> <p>Symptoms indicating complications:</p> <ol style="list-style-type: none"> <li>6. Fever</li> <li>7. Persistent vomiting</li> <li>8. Abnormal vaginal discharge/itching</li> <li>9. Palpitations, easy fatigability</li> <li>10. Breathlessness at rest/on mild exertion</li> <li>11. Generalized swelling of the body, puffiness of the face</li> <li>12. Severe headache and blurring of vision</li> <li>13. Passing smaller amounts of urine and burning sensation during micturition</li> <li>14. Vaginal bleeding</li> <li>15. Decreased or absent fetal movement</li> <li>16. Leaking of watery fluid per vaginum (P/V)</li> </ol> <p>Previous pregnancy / obstetric history</p> <ol style="list-style-type: none"> <li>17. Live births, stillbirths, abortion, child death, etc.</li> <li>18. Previous outcome of events along with birth weight.</li> <li>19. Complications in previous pregnancy like recurrent early abortion / Post-abortion</li> </ol>	<p>General examination</p> <ol style="list-style-type: none"> <li>1. Pallor</li> <li>2. Pulse</li> <li>3. Respiratory rate</li> <li>4. Jaundice</li> <li>5. Edema</li> <li>6. Blood pressure</li> <li>7. Weight</li> <li>8. Breast examination</li> </ol> <p>Abdominal examination</p> <ol style="list-style-type: none"> <li>9. fundal height</li> <li>10. Fetal Heart Sounds</li> <li>11. Scars</li> <li>12. fetal lie and presentation</li> </ol>	<ol style="list-style-type: none"> <li>1. Urine Pregnancy test</li> <li>2. Blood investigations for Hemoglobin estimation and blood grouping including Rh factor</li> <li>3. Urine test to assess the presence of sugar and proteins</li> <li>4. Rapid test for malaria and syphilis</li> </ol>

complications / Breech / Puerperal sepsis 20. History of blood transfusions 21. Caesarean sections / removal of the placenta Past history of illness 22. Hypertension 23. Diabetes 24. Heart disease 25. Renal disease 26. Epilepsy 27. Asthma 28. Jaundice 29. Malaria 30. Family history of systemic illness (HIV/STI/RTI)		
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Table 2.1 Components of Ante natal check-up

### III. Amalgamation of IoT & ANC

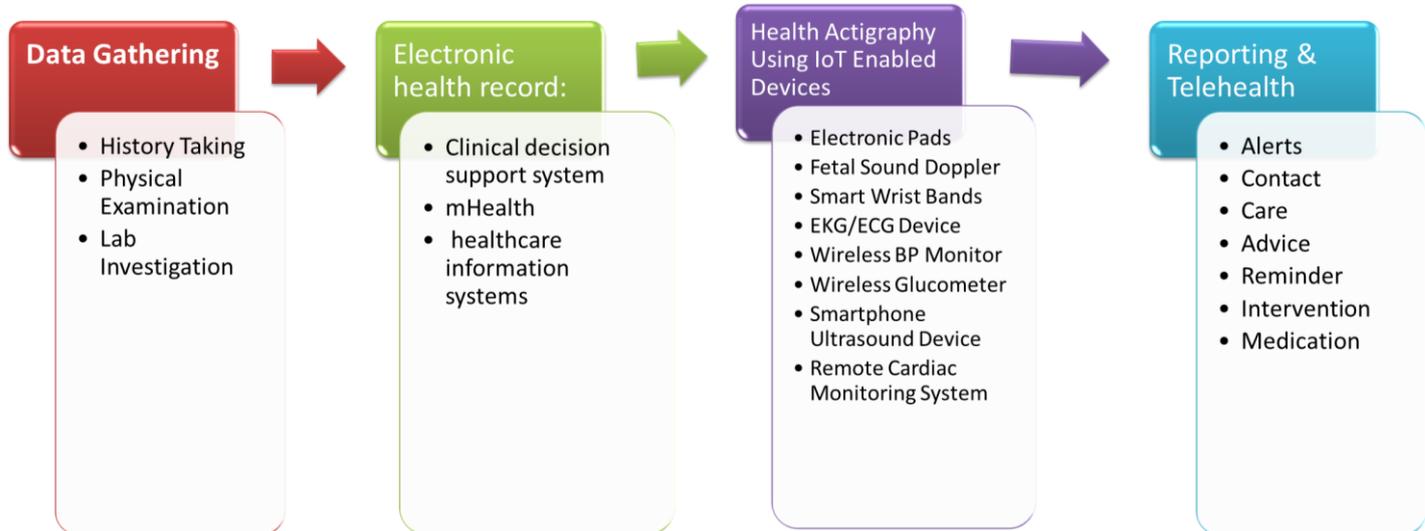


Figure 3.1 Flow of IoT Enables ANC & Monitoring

Processor combining IOT with ANC starts with data gathering in which past medical history of mothers should be taken carefully. Physical examination records also gathered for analysis & reporting purpose. It will help medical staff to track mothers health & needful services to her occasionally. Date gathering is done with paper based forms which will later converted to digital using health information system by data entry operators posted on primary health centers respective area. mHealth system used to store and process initial examination records of mothers health for further activity tracking. Clinical decision support system provides determinations, judgments, and courses of action to doctors and ANMs based of gathered records & current situation of mothers health. Actigraphy devices are useful equipment's for monitoring human rest/activity cycles because many of rural women's do labor work during pregnancy which is perilous for mother & child both. To track their activity smart wrist bands can be used to collect data about their activities & rest cycles which will led medical staff to give her knowledge about risk of situation & direct her to maintain healthy pregnancy. Reports can be also generated by collected data which could be analyzed through data analytics algorithms for fact findings which supports medical staff to perform needful operations & action to take proper care of mothers health. A mobile application can be also used to store details of mothers & statistics that can used to generate alerts, warnings, reminders, based on real-time health records for mother & medical staff respectively, using this application doctor can recommend telemedicine for primary treatment & id required then emergency service could be dispatched to mothers location.

#### IV. Devices & Applications for IoT Enabled ANC

For ANC it is difficult to mobile huge medical equipment for investigation & examination. Here are list of some devices that could be helpful

1. **Sound Fetal Doppler:** A ubiquitous digital listening device than the old stethoscope this device serves as a hand-held fetal doppler to monitor heart rate through embryo. The machine, used from ten to twelve weeks into pregnancy, allows mothers & doctors to hear the heartbeat and displays the rate on an LCD screen.
2. **Smartphone Enabled Electrocardiogram:** ECG is a portable, compact, wireless, user- friendly electrocardiogram device with finger and chest electrodes.it has high- resolution screen that displays the ECG waveform & also synchronize data with smartphone using its application.
3. **Portable Gluten Tester :** For collecting data about zinc, selenium, and folic acid deficiency in pregnant women’s PGT has one-time use test capsules and a smart phone application that allows you to track and share data among digital devices, the small sensor could be a lifesaver for mothers with gluten allergies or celiac disease.
4. **Wireless BP-Monitor:** Wireless blood pressure monitor comes smart phone application gives medical staff instant color-coded feedback and professional suggestions, and makes it easy to keep track of mothers measurements.
5. **Wireless Smart Gluco-Monitor System:** Most pregnant women have a glucose screening test between twenty four and twenty eight weeks of pregnancy. The test may be done earlier if mother have a high glucose level during her routine checkup visits, or if she have a high risk for diabetes. Smart gluco-monitor measures glucose levels in the blood and then displays them on your smartphone. Application installed in smart phone gather data with monitor & can also keep history for analysis which can be further used by medical staff for treatment.
6. **Smartphone Ultrasound Device:** It is specially designed for medical professionals to diagnose patients in remote areas. It’s small, ubiquitous ultrasound wand is compatible with smart phones. It can be used for monitoring pregnancies & various abdominal, cardiac, pelvic, and peripheral vessel scans. Images are stored on an microSD card and also can be shared via Wi-Fi, mobile networks, or USB.
7. **mHealth:** mHealth is an abbreviation for mobile health, a term used for the practice of medicine and public health supported by mobile devices<sup>[5]</sup>. It uses devices, such as mobile phones, tablet computers and PDAs, and wearable devices such as smart watches, for health services, information, and data collection. It deliver healthcare information to doctors, researchers and patients, real-time monitoring of patient vital signs, the direct provision of care via telemedicine as well as training and collaboration of medical staff<sup>[6]</sup>.

Data collected from this devices can be directly shared with doctors and ANMs using smartphone & mobile networks which could help medical staff to monitor, track, analyze, advice, care, & treat mother remotely via telemedicine.

#### V. Role of Healthcare Analytics in ANC

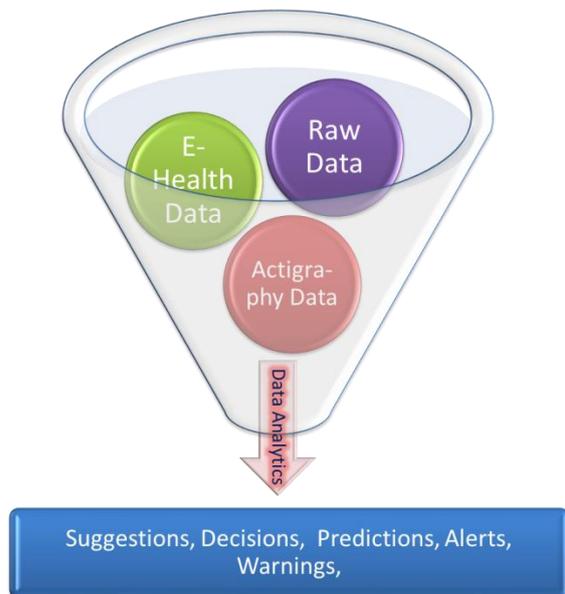


Figure 5.1 Role of Data Analytics in ANC

Healthcare analytics is a process of inspecting, cleansing, transforming and modeling patients data with the goal of discovering useful information, informing conclusion and supporting decision-making. Amalgamation of deep learning and analytics algorithms can make useful visualizations and predictions based on raw data. The bodacious positive impact of analytics can have on the pressures health systems face to be more efficient and improve medical outcomes. In ANC data analytics could help medical staff to visualize patterns of facts that are useful to gain awareness about mother’s health & future medical treatments. Data analytics could help medical staff to optimize its performance in decisions making.

## VI. Advantages of IoT Enabled ANC

IoT enabled ANC have many tangible & intangible benefits that could lead to smooth functioning of ANC in rustic areas where typical medical machinery are not availed for examinations & investigation. Few Advantages of this approach are listed below.

1. **Disease detection** – With real-time data PHC's medical staff can continuously monitor mother's health related statistics. It helps detect any disease before it spreads and becomes serious to her & child's health.
2. **Decreased costs** – With IoT, mother's monitoring can be done in real-time, drastically cutting down the need for medical staff going out and making visits to her location. Connected home care facilities will also help reduce hospital's & mother's costs.
3. **Finer pregnancy duration** – A well connected medical staff & mother creates an environment that meets each individual mother's needs in rustic zone. Dedicated support, emergency treatment options and enhance diagnosis make for a better pregnancy experience.
4. **Lessen errors** – IoT allows for the accurate collection of data, automated workflows and minimized waste, but most importantly it reduces the risk of error
5. **Domiciliary Care** – IoT allows patients to be monitored in the comfort of their own place. Ubiquitous devices availed onto various pieces of medical gadget (e.g. wireless heart rate monitors) at the home of mother's. The data gathered is sent to the PHC where a medical staff checks it for any peculiarity.

## VII. Challenges & Future

Storing different set of data collected by many different devices will pose a challenge to the health organization like PHC's. As this data will also be shared among devices, the security issues will also arise. Unauthorized access to connected devices can cause harm to the mother's safety. Thus, proper authentication and authorization will be necessary to achieve success with IoT enabled ANCs. Programs that IoT has to offer are not fully developed yet. The extensive connected devices in the diases diagnostic model is also incomplete. IoT and ANC together will radically change the service offerings in the PHCs situated in rustic areas.

## VIII. Conclusion

The complete application of this paradigm in ante natal checkup is a mutual hope because it allows primary health centers to function more competently and patients to obtain better treatment in rustic locations. With the use of IoT enabled ANC, there are unparalleled benefits which could improve the quality and efficiency of treatments and accordingly improve the health of the mothers.

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