

# Reducing Early-Infant Mortality: A Review of Advances in Diagnosis, Clinical Management and Artificial Intelligence-Driven Technologies

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**Abstract:** Neonatal diseases which are the diseases experienced at early infancy remain the leading cause infant mortality globally. The ability of a baby to survive the infant phase depends to a large extent on his chance of survival of the first 28 days of life. The main cause of high mortality of these early infants has been found to as a result of error in diagnosis. In spite of several techniques being employed by clinicians there is still a need to seek a timely and accurate method to aid the diagnosis of neonatal ailments. This paper conducted a structured review of the trends and milestones in newborn health management. Studies were made on the practices in the early days of neonatology, the currently available methods of mitigating the rate of neonatal mortalities and morbidities were also described. The adoption of some promising solutions and technologies such as machine learning, artificial intelligence (AI) and internet of things (IoT) for the detection of neonatal diseases more accurately in the future was also reviewed. The study presented a pathway of improvement on the conventional techniques to more efficient advanced technologies for newborns survival.

**Keywords:** Neonatal Diseases, Mortality, Diagnosis, Machine Learning, Artificial Intelligence, Internet of Things.

## 1. Introduction

The life phases of a baby from conception to birth are described as embryo from 0 to 2 months, fetus from 2 to 9 months and neonate the point of birth to the first 4 weeks of life as represented in Figure 1. Neonatal period is a period of transition of fetus to the real world human [1]. It is the critical phase of life when the newborn begins to adapt to life outside the mother's womb. The separation from the placenta which has facilitated the exchange of gases, nutrition, blood circulation and extraction of wastes from the fetus creates needs for physiological adjustment and adaptation. Thus, it is the time when some of the major physiological changes happen in humans' life [2]. The time of these changes are not the same throughout the body system, some parts like the cardiovascular and respiratory systems change immediately a child is born but others like reproductive organs evolve gradually over time to produce a complete adult physiology [3].

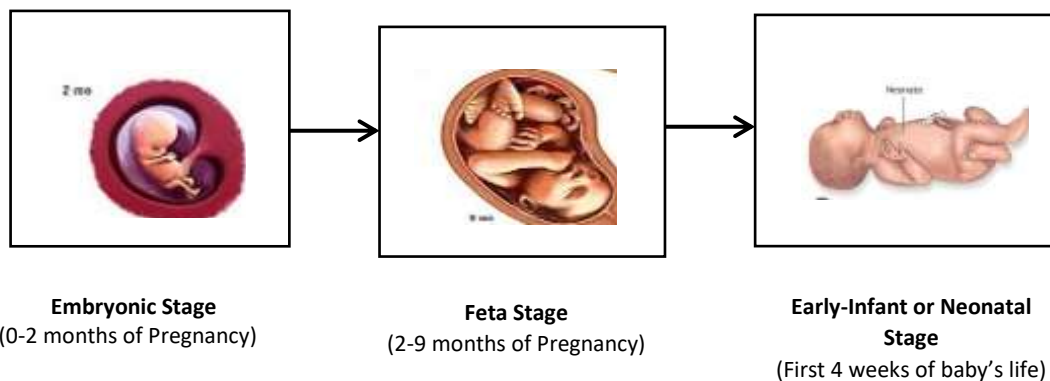


Figure 1: Baby's phases of development – from conception to newborn

Newborns' survival depends on heart rate for cardiac output because they have decreased ventricular compliance. Vascular

pressures change in neonates as they are exposed to more oxygen. When born, the exposure of neonates to more oxygen and lesser prostaglandins lead to the closure of the ductus arteriosus (PDA), thus helping to increase blood flow to the lungs. Newborns are prone to oxygen desaturations because of the reduction in the functional residual capacity (FRC) and as such, they need about twice the level of oxygen needed by adults [4]. At births, babies come with fetal hemoglobin (HbF), which has 70-90% hemoglobin molecules and continue in the baby's system for three months. This makes neonates to possess lower oxygen pressures than adults [5].

Neonates' brains are deficient in cerebral auto-regulation system which regulates blood perfusion of the brain whenever there is an extreme blood pressure. At such increased blood pressure, the neonate is prone to intra-ventricular hemorrhage because some of the fragile blood vessels may rupture. Newborns have little or no means of preventing heat loss; they easily lose body heat because they usually possess high body surface area to weight ratio [3]. These and other features make neonates very susceptible diseases and abnormal functionality of the body systems. Since the organs and body systems are still very fragile and underdeveloped, a little disorderliness in the system can result in serious health complications and if not properly managed may result in total system collapse or shut down leading to death [6]. Efforts to mitigate these risks are what gave birth to neonatology, a special field that focuses on the health of newborns.

### *1.1 Evolution of Neonatology*

Neonatology is a branch of pediatrics that specializes on the medical care of babies (especially the sick and preterm) within four weeks of age. Historically, management of the health of newborns has faced several controversies, as well as the challenges of ethical, religious, cultural and political views of various nations and societies. The last 150 years have witnessed many changes in neonatal morbidity and mortality. These were the foundation for the birth of the ideas and technologies in perinatology and neonatology [1]. Neonatology as a rapidly developing field of medical specialty became popular in 1960s as Shaffer introduced the term neonatology in 1963 to describe newborn diseases and their treatments. As the World War II ends in the 1960s, pathophysiology and neonatal physiology began to develop, thus providing insights into neonatal ailments and their treatments [7]. This seems to be the birth of neonatology as physicians who were interested in neonates began to increase in the 19th century, although most of them were obstetricians. Not until the second half of the 19<sup>th</sup> century before the understanding of the treatments of preterm babies became clear. Before then, efforts were only devoted to correct determination of babies of birth weight, feeding ability, and incubating devices [1,8].

Before 1960, several authorities in the field of medicine and healthcare have pointed out the need for this specialized medical field. Ballantyne in 1923 suggested that some doctors and nurses as well as teaching and construction of medical facilities should be separated for intensive training in the management of delicate newborns [9]. Grulee in 1939 opined that the obstetricians who were in charge of the problems of the newborns have only very little to contribute the management of the diseases of the neonates [10]. Interest in the welfare of newborn infants continue to grow until 1948 when the American Academy of Pediatrics (AAP) published a book titled "Standards and Recommendations for Hospital Care of Newborn Infants" and in 1952, Virginia Apgar presented a paper to the anesthesia research societies on neonatal assessment in the delivery room which focused attention on the newborn infants.

Although many preterm baby nurseries were in available in the 1930s to 1940s with several books relating to the care of newborns already published [11], there was a sudden increase in the number of pediatric doctors who are interested in the newborn-care in the middle 20th century. Thus the core tasks of newborn-care shifted from the obstetrician to the pediatrics. Interest in newborn healthcare increase rapidly, leading to major changes in infants health care. Thus in 1970s, the idea of reduction of blood samples to serum electrolyte, blood gas, bilirubin and testing of the function of liver was developed [10]. There were more technology-based methods of managing premature babies in the 1990s. A more formal profession of premature babies care also began to form. These enhanced the survival of babies who in few years past had no hope of survival [8]. The major neonatal diseases are prematurity, jaundice, birth asphyxia, pneumonia, sepsis, meningitis, respiratory distress syndrome, congenital malformation, neonatal tetanus and hemolytic disorder. However, due to environmental factor being one of the main causes that influence the occurrence of these diseases, some are more common or peculiar to some geographical location. Therefore, those that are commonly experienced in southwestern part Nigeria are what this research is focusing on.

## **2. Neonatal Healthcare**

Neonatal health is a very sensitive branch of pediatrics that is concerned with the well-being of babies during the first four weeks of life. This period is crucial for the child's development and overall health, as they transition from the protected environment of the womb to the outside world. Neonatal diseases can have a significant impact on newborns and their families, leading to serious complications in the health, emotional and financial distress. Adequate knowledge of the importance of newborns' health and the impact of neonatal diseases are necessary to be able to effectively manage the health of neonates [8,2]. This period is a time of rapid growth and development, during which infants are highly vulnerable to infections, diseases, and other health issues. Proper neonatal care can prevent long-term health complications and disabilities that may arise from untreated neonatal diseases [12].

Neonatal diseases refer to health conditions or illnesses that newborn babies may experience within the first 28 days of life. These diseases can be congenital (present at birth) or acquired after birth, and they may range from mild, self-limiting conditions to more serious, life-threatening illnesses. Neonatal diseases require prompt diagnosis and treatment to ensure the well-being and survival of the newborn [13]. These diseases can range from common conditions such as jaundice and respiratory distress syndrome to more severe illnesses like sepsis and congenital heart defects. Neonatal diseases are major problems confronting newborns, there is therefore need for timely detection and treatment in order to prevent the risk of complicated health condition, and ensure optimal outcomes [14]. Likely complications that may result from delay in diagnosis of neonatal diseases are delay in body system development, preterm birth or low birth weight and neurological disorders [8]. It can place a heavy emotional and financial burden on families, as they require extensive medical care, hospitalizations, and long-term treatment. The impact of neonatal diseases extends beyond the immediate health of the newborn, affecting the family's emotional well-being, social interactions, and financial stability.

Here are the common neonatal diseases affecting newborns include Respiratory Distress Syndrome (RDS): a breathing anomaly in neonates, especially premature babies, RDS occurs due to the immature lungs' inability to produce enough surfactant, leading to breathing difficulties. Jaundice is one of the commonest health disorders in newborns. It is characterized by yellowish colouration of the eyes and skin, caused by excess bilirubin in the baby's blood [5]. It is often treatable with phototherapy or, in severe cases, exchange transfusion. Sepsis: this is an infection in the bloodstream as a result of fungi, bacteria or viruses. Early recognition and treatment with antibiotics are crucial to prevent complications. Hypoglycemia refers to low blood sugar levels in newborns can lead to symptoms such as irritability, poor feeding, and seizures. Prompt feeding or intravenous glucose administration is necessary to raise blood sugar levels. Congenital Heart Diseases are abnormalities which occur in the structure of the heart. It is usually discovered at birth and can affect the heart's function and blood circulation. These defects may require monitoring, medications, or surgical interventions [15].

Neonatal abstinence occurs when newborns are exposed substances which the mother had been addicted to, such as opioids, at pregnancy. Symptoms include irritability, feeding difficulties, and tremors, requiring supportive care and weaning from the substance. Perinatal Asphyxia: Perinatal asphyxia is a condition where the newborn experiences oxygen deprivation during birth, leading to potential brain damage and organ dysfunction. Immediate resuscitation and supportive care are essential to prevent long-term complications. Newborns are also vulnerable to infectious conditions such sepsis, meningitis and pneumonia because of their weak immune systems. Prompt diagnosis and treatment with antibiotics are crucial to prevent further complications [14]. Early recognition, diagnosis, and appropriate management of these conditions are essential to ensure the health and well-being of newborns during the neonatal period.

### *2.1 Risk Factors of Neonatal Diseases*

Risk factors are the behaviors, conditions and characteristics that increase the chances of contacting or developing a disease. Causes or what led to the development of an ailment are not always one factor operating alone but many factors linked together or co-exist and interact with one another leading to the development of certain health conditions [14]. Understanding the risk factors that contribute to neonatal diseases is crucial for early detection, prevention, and effective management. Maternal health may cause maternal infections during pregnancy, such as syphilis, HIV, and Group B streptococcus, can be transmitted to the newborn and increase the risk of neonatal infections. Maternal lifestyle factors, including smoking, alcohol consumption, and drug use, can impact the health of the fetus and contribute to neonatal complications. Premature Birth refers to the preterm infants, born before 37 weeks of gestation, are at increased risk of developing respiratory distress syndrome, infections, and other neonatal complications. Low birth weight and underdeveloped organ systems in preterm infants can pose challenges for their health and development. Birth Trauma is difficult labor, birth injuries, and complications during delivery, such as meconium aspiration syndrome or birth asphyxia, can increase the risk of neonatal diseases. Thus, trauma during birth can lead to neurological, respiratory, and musculoskeletal problems in newborns.

There are also genetic factors which are inherited genetic disorders, chromosomal abnormalities, and congenital malformations can predispose infants to neonatal diseases. Genetic testing and counseling are essential for identifying high-risk neonates and providing appropriate medical care [5]. It must be noted that neonatal diseases are seriously influenced by environmental factors, such as pollution, exposure to toxins, and inadequate access to healthcare services. Socioeconomic disparities and lack of prenatal care can contribute to poor neonatal outcomes in vulnerable populations. The identification and understanding of risk factors contributing to neonatal diseases are crucial for promoting newborn health and reducing morbidity and mortality rates. Early detection, comprehensive prenatal care, and targeted interventions can mitigate the impact of these risk factors and improve neonatal outcomes [4]. Further research and public health initiatives are needed to address the complex interplay of factors influencing neonatal health.

### *2.2 Past Management of Neonatal Diseases*

Historical methods of handling neonatal conditions were much limited due to the low level and standard of technological advancements and thus these methods were largely ineffective often leading to high mortality rates. Notable steps were made in the 20<sup>th</sup> century by Martin Couney and his *publicizing* incubators, which highly more recognized majorly for the demonstrative benefits they bring in public fairs. After Martin's incubators came the discovery of Penicillin, which was the first and broadly used generally effective antibiotic for which its discoverers Alexander Fleming, Howard Florey and German Ernst Chain became Nobel laureates for their work in coming up with the first antibiotic that prevented many deaths due to bacteria infections which had been killing thousands of lives *including newborn children* during World War II. Let us look at these two monumental achievements in history and their specific applications in reducing the then high rates of Neonatal deaths [14].

#### *The Discovery of Incubators.*

An incubator's general working idea is to keep pre-term babies born prematurely in an environment that imitates the intravenous conditions of the human-female womb before releasing the child with enough strength into the external world to develop in normal environmental conditions. Incubators had earlier been designed and developed prior to the 1930s before they became popularized by Martin Couney [16]. Couney was the first with his predecessor to demonstrate his self-designed incubators in a most public way (at the World Trade Fairs) emphasizing on how these *baby containers* can help save many if not all premature infants from death due to the under-developed physiological conditions of their body's subsystems and thus helping to reduce the rates of death below 85% of the fatality rate at that time [17].

#### *The Advent of Antibiotics: Discovery of Penicillin*

Alexander Fleming, a doctor with a degree in bacteriology in 1928 discovered penicillin or at least the presence of penicillin in a bacteria culture embedded with *moulds* (the penicillin producers) and found out in his observation that some secretion from those moulds formed whitish-rings around those moulds. that the bacteria population could not come close to. Later than Fleming would find out that, that substance taking the appearance of a whitish ring is penicillin and its wide-spread use would help reduce greatly the rate of neonatal deaths due to neonatal infections [2].

### *2.3 Present Management of Neonatal Diseases.*

Presently the management of neonatal diseases has been through physical observations to make diagnosis for treatments. These involve clinical screening for the purpose of detection of symptoms of neonatal diseases and by providing nutritional support.

#### *Screening and Early Detection*

With the high hopes of clarifying uncertainties in possible child-birth crises, screening exercises for every child have now been standardized in almost every child-birth center thus enabling the early detection and treatment of metabolic, genetic and endocrine disorders outcomes [16]. Emphasizing on early screening and detection ensures that subtle and dangerous child birth associated disorders receive timely intervention thus preventing long-term complications in the child and ensuring timely and effective treatment [2].

#### *Nutritional Support*

According to the American Academy of Pediatrics, at the time of publication, 21% of the US infant mortality at the time has been attributed, in part, to the increased rate of Sudden Infant Death Syndrome (SIDS) in infants who were never breastfed [8]. Having proved scientifically the many benefits of child-breastfeeding, such as increased immunity and improved cognitive development, proper nutrition is tremendously vital in neonatal care. And as for babies who cannot breastfeed, specialized formulas and parenteral nutrition diets have been prepared to ensure adequate growth and development of both parent (Mother) and the concerned child.

#### *Pharmacological Interventions*

Surfactants, which are chemicals that reduce the surface tension of the lungs have been introduced and have gained widespread use thus significantly improving the respiratory conditions of infants with Respiratory Distress Syndrome. Also advancements in antibiotics and antiviral medications have helped provide adequate and timely prevention and treatment of childbirth diseases [7,18].

All these interventions as good as they are depend of human observations and decisions for diagnosis. Pediatricians especially in countries with limited resources are always pressured with large numbers of neonatal patients which usually result in stress and fatigues leading to misdiagnosis. Neonatal diseases have related and very similar symptoms, this affects the accuracy of physiological observations for diagnosis. Published studies have shown that the rise in neonatal mortality is more of diagnostic errors than severity. Diagnostic errors are either caused by delay diagnosis; inability to reach a conclusion on the type of ailment on time, or misdiagnosis [19]. Therefore, there is a need to seek advanced technologies such as artificial intelligence (AI) techniques internet of things (IoT) and hybrid AI-IoT systems, which are less prone to diagnostic errors in order to increase the survival rate of newborns globally.

### **3. Artificial Intelligence Aided Technology: The Future of Neonatal Disease Management**

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Artificial intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think like humans and mimic their actions. The term may also be applied to any machine that exhibits traits associated with a human mind such as learning and problem-solving. According to the father of Artificial Intelligence, John McCarthy, it is “The science and engineering of making intelligent machines, especially intelligent computer programs” [20]. Artificial Intelligence is a way of making a computer, a computer-controlled system, or a software think intelligently, in a manner similar to humans. The ideal characteristic of artificial intelligence is its ability to rationalize and take actions that have the best chance of achieving a specific goal. A subset of artificial intelligence is machine learning, which refers to the concept that computer programs can automatically learn from and adapt to new data without being assisted by humans. Deep learning techniques enable this automatic learning through the absorption of huge amounts of unstructured data such as text, images, or video. Artificial intelligence is based on the principle that human intelligence can be defined in a way that a machine can easily mimic it and execute tasks, from the most simple to those that are even more complex [21].

The goals of AI are [22]:

- (i) to Create Expert Systems: The systems which exhibit intelligent behavior, learn, demonstrate, explain, and advice its users.
- (ii) to Implement Human Intelligence in Machines: Creating systems that understand, think, learn, and behave like humans.

These goals make AI a very appropriate compliment for future healthcare delivery, especially in sensitive areas like neonatology. There are different categories of AI, it is broadly categorized into data-driven and knowledge-driven approaches. Machine Learning (ML) and Deep Learning (DL) represents a data-driven paradigm that enables systems to learn patterns from data, while Expert Systems (ES) embody knowledge-driven AI through rule-based reasoning [20]. Figure 2 illustrates the relationship between artificial intelligence, expert system, machine learning and deep learning.

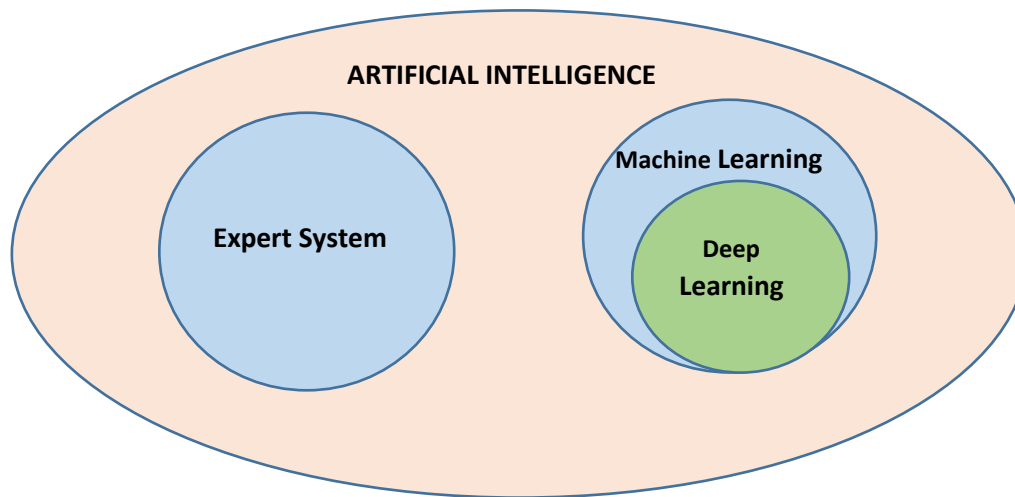


Figure 2: Illustration of the relationship between AI, ES, ML and DL

### 3.1 Knowledge-Based AI: Expert Systems

Expert Systems are the knowledge or rule-based AI systems that emulate human decision-making or expertize using a structured knowledge base and inference mechanisms [23]. As shown in Figure 3, the key components of an expert system are the Knowledge Base (containing facts and rules), Inference Engine and the User Interface.

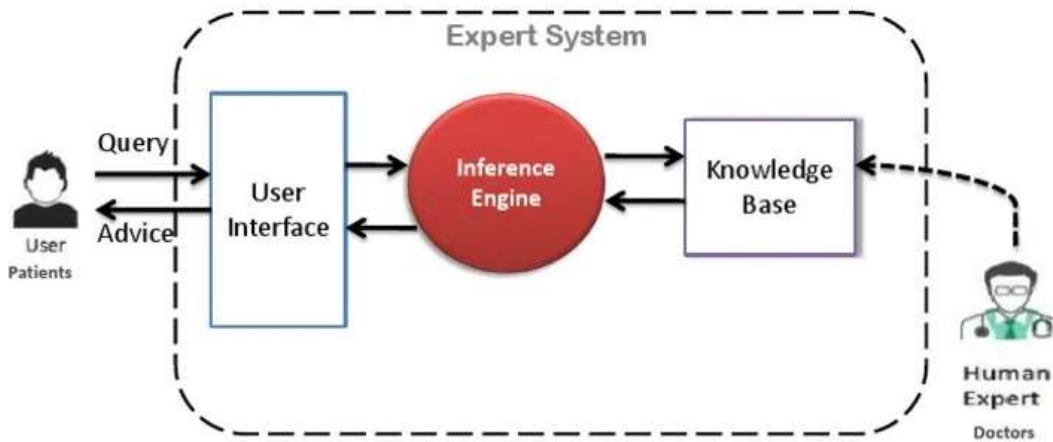


Figure 3: The architecture of an expert system [24]

Although limited in adaptability, expert systems are known for being deterministic in decision making and transparent in reasoning because of their rules (if-then-rules). It finds applications mostly in equipment or production process fault diagnosis, legal reasoning and clinical decision supports [25]. There are different types of Knowledge-Based AI, those that related application to medical diagnosis are:

- i. Rule-Based expert systems
- ii. Frame-Based systems
- iii. Semantic Network-Based systems
- iv. Fuzzy expert systems
- v. Model-Based expert systems

*Mathematical model of Expert Systems (Knowledge-Based AI)*

The knowledge based component of the system is made up of rules and facts which is represented as [26]:

$$K = (F, R) \tag{1}$$

the facts;

$$F = \{f_1, f_2, f_3 \dots, f_n\} \tag{2}$$

where  $f$  represents the each of the component fact or truth

the rules;

$$R = \{r_1, r_2, r_3 \dots, r_n\} \tag{3}$$

where  $r$  represents the each of the component rule

each rule is expressed as:

$$r_i : IF = \{a_1 \wedge a_2 \wedge a_3 \dots \wedge a_k\} \rightarrow b \tag{4}$$

based on propositional logic

The inference engine component applies rule to the facts to come up with new knowledge, thus:

$$F_{i+1} = F_t \cup \{b | (a_1 \wedge a_2 \wedge a_3 \dots \wedge a_k) \rightarrow b \in F_t, a_i \in F_t\} \tag{5}$$

*3.2 Learning-Based AI: Machine Learning and Deep Learning*

Machine Learning is a branch of AI that makes systems to automatically learn and improve from experience without explicit programming. Deep learning is a subset of machine learning that employs multiple layers of neural networks for learning complex

patterns [27]. As shown in Figure 4:, the major components of machine learning are the dataset or data source, data preprocessing and the machine or deep learning algorithm

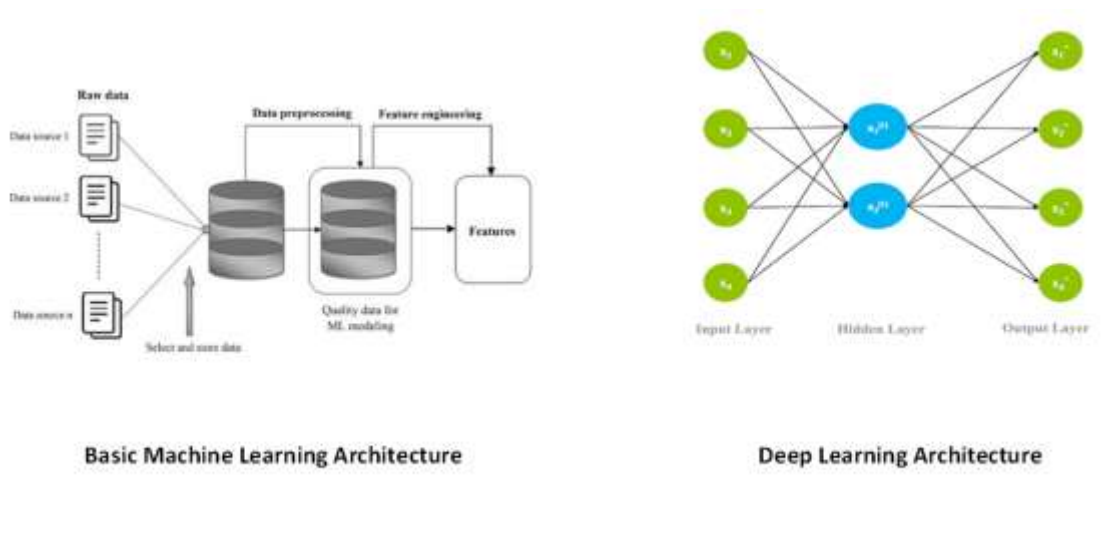


Figure 4: Architectures of ML: Basic machine learning and the Deep learning [28]

Machine learning AIs are data-driven (learn patterns in dataset), capable of handling uncertainties, scalable and adaptive. They are applied in fields such as image recognition, prediction of process outcome, natural language processing and medical diagnosis. The major types of machine learning techniques are [29]:

- i. Supervised learning algorithms, where the model is guided through its training on labeled dataset.
- ii. Unsupervised learning algorithms, where the model to identify complex patterns without any guide.
- iii. Reinforced learning algorithms, where the model learns by taking actions and receiving feedbacks to improve outcome.

Although, every machine learning algorithm has its mathematical model, a simple machine learning process could be represented linearly as [30,31]:

$$\hat{y} = (wx + h) \quad (6)$$

where  $\hat{y}$  is the expected output based on the input feature ( $x$ ), weighted by a parameter ( $w$ ), with the addition of the necessary bias ( $h$ ).

Thus, the model learns by varying  $w$  and  $h$  to maximize accuracy.

### 3.3 Hybrid AI: Machine Learning-Expert System

In spite of the individual potentials of the two categories of AI, both still possess some limitations; machine learning models usually lack interpretability and expert systems have the problem of rigidity and very little adaptability. Hybrid AI systems whose architecture is represented in Figure 5 combines Machine Learning and Expert Systems to leverage both adaptive learning and logical reasoning. This integration addresses key challenges such as lack of explainability in ML and rigidity in rule-based systems [24,32].

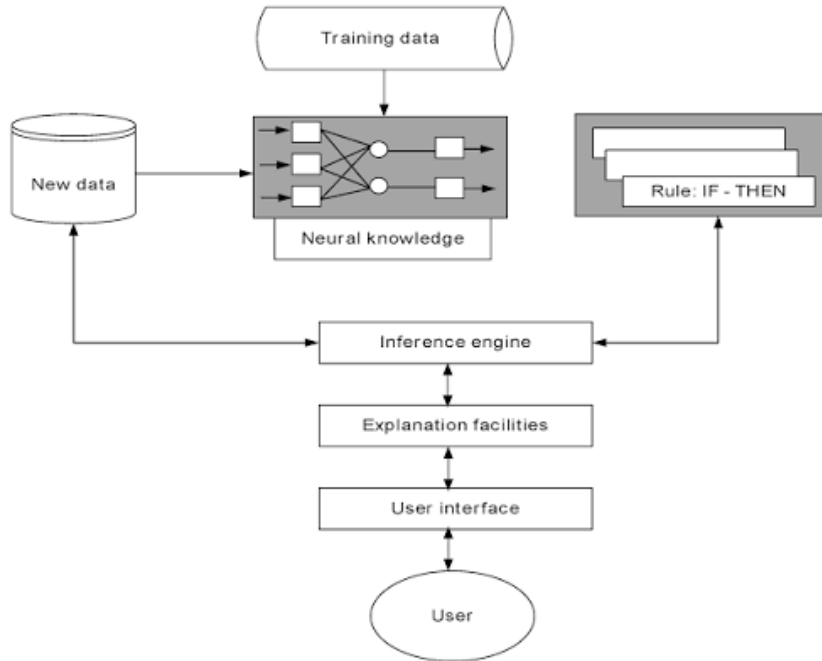


Figure 5: The architecture of the hybrid machine learning-expert system AI [33]

Being a derived model, there is not rigid structure for the expert system-machine learning architecture. Every architecture is designed based on the purpose, sometimes ML is used to improve the knowledge base, and some tasks require that the rules be incorporated into the ML models. In using the hybrid AI, the ML is able to detect the complex patterns (especially in medical records), while the expert rules enforce the necessary guidelines (diagnostic guidelines). Therefore, hybrid AI is capable of being employed in Clinical Decision Support Systems (CDSS) to enhance its interpretability and diagnostic accuracy [32,33].

Neonatal mortality is more in low income communities, developing nations and in environments with limited resources where there little or no access to comprehensive health facilities [19]. The use of AI hybridized with other state-of-the-art technology such as the Internet of Things (IoT) will facilitate remote medical intervention and telemedicine [34].

### 3.4 Internet of Things

Thus, Internet of Things (IoT) is a technology involving interrelated computing systems, objects, machines, animals or human with special identities and have capabilities for data transmission on real-time over a network without necessarily involving human interaction [35,34]. A “thing” in IoT system may be a newborn with sensors to alert the caregiver when the temperature rises, a software monitoring the identity of internet users, human having an implant heart monitor, a farm animal/plant with biochip or any other object that could be assigned an Internet Protocol (IP) address and able to communicate over a network [11,36]. As represented in Figure 6 IoT operates in layers, the number of layers depends on the task but there are four basic layers that IoT is built upon; sensing, processing, network and application layers.

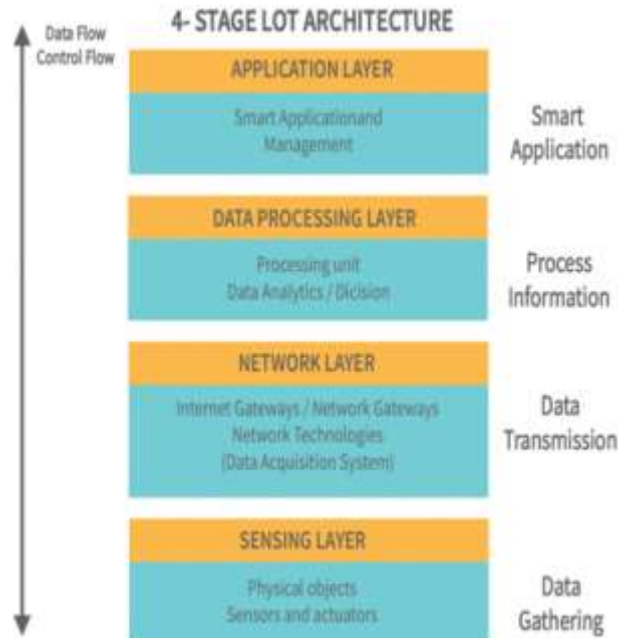


Figure 6: The four layers in IoT architecture [34]

IoT has the following advantages in favour of neonatal healthcare:

- i. Efficient automation
- ii. Cost effective
- iii. Compact and easy integration
- iv. Improves decision making
- v. Real-Time operation
- vi. Scalability

IoT employs various sensors and actuators at the sensing/perception layer to collect information (which is converted from physical to digital form) from the target for transmission over the network layer. The collected information is transmitted over appropriate communication technologies such as zigbee, bluetooth, Wi-Fi, WAN or 4G/5G networks to the processing layer. The processing layer which could be edge, fog or cloud computing stores, processes and analyzes the data for the end user at the application layer [34].

Some critical tasks such as those involving biomedical signals require timeliness and high accuracy in decisions; therefore, there is need for a more advanced technology. In such cases the advanced IoT paradigm – edge AI-IoT shortened as AIoT is employed. This is a machine learning-enabled internet of things system. It integrates ML model into an IoT structure to enhance intelligent data collection (sensing), prediction and auto-decision making. A typical architecture of an AI-IoT system is as shown in Figure 7.

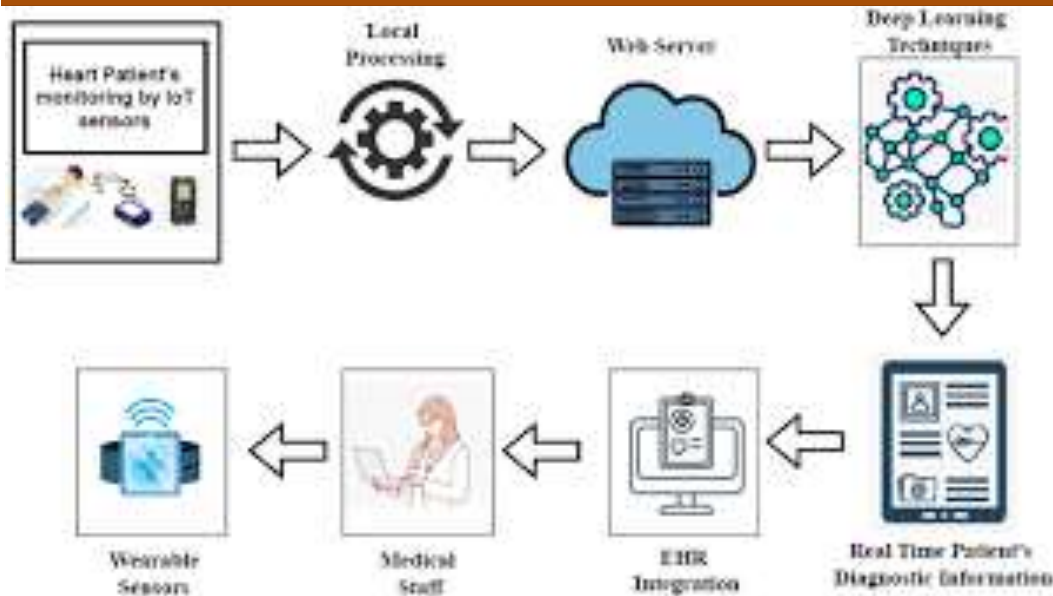


Figure 7: The architecture of an ML-IoT system for medical diagnosis [37]

This is a distributed intelligent architecture of IoT devices which are collecting and transmitting information as well as learning underline patterns to make useful predictions using machine learning or deep learning models on edge environments. Available publications have shown that research efforts are ongoing around the globe in attempt to examine the possibilities of employing AI and AI-based technologies to aid neonatal diseases management.

### Conclusion.

This study has shown that the development of neonatal care has improved over the years from conventional observation to technology enhanced techniques. In spite of the advances in the clinical methods of neonatal health management, neonatal mortality continues to be a major health concern especially in resource constraint settings. The review has revealed that the cause of the high mortality is more of errors in diagnosis than diseases severity. The introduction of cutting-edge technologies such as AI, ML and IoT presents a pathway to address the gaps. These emerging technologies have the abilities for real-time monitoring of sick neonates, making precision diagnosis and decision support that goes beyond human-based clinical diagnosis.

The hybridized model of expert system and machine learning is promising development in AI that enhances accuracy and interpretability of neonatal diseases diagnosis. A further improvement on AI to AIoT (AI-IoT) system favours a cheap, compact and scalable system that is needed for remote diagnosis and medical support through telemedicine. However, before these technologies could be deployed, challenges relating to ethical considerations, data security, data quality, culture and acceptability must be addressed.

Reducing neonatal mortality requires inter-discipline efforts that combine emerging technologies with improved healthcare systems, research oriented medical practice and sound maternal care. Future studies should focus on the physical development, evaluation and deployment of these intelligent systems for neonatal health care and as supports in other applicable areas of health system. This study which connects the conventional to the intelligent medical support has shown clearly the path to significant reduction in neonatal mortality in no distant future.

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