CLINICAL INDICATOR ANALYSIS FOR PREDICTING PATHOGENIC PNEUMONIA INFECTION IN NEWBORNS WITH DISTRIBUTED SENSOR NETWORKS DATA ANALYTICS

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Abstract. Neonatal infections are prevalent as newborn children are prone to a range of infections because of their absence of immunity. Being susceptible to various diseases, the immune system of infants is not adequately developed to fight against protozoa bacteria, viruses and parasites. Pathogenic pneumonia is one of the most common infections identified within the neonatal group. It is a lung infection occurring in the neonates, which can start after a few hours of delivery or even after a week. The infection can even occur due to the normal flora found in the genital tract of the mother, and the respiratory distress caused by pathogenic pneumonia can even lead to the infant's death. The study examined the clinical indicator for assessing the occurrence of pathogenic pneumonia in infants. With the help of sensor networking in data analytics, the prediction of such a disorder has been assessed in-depth in the article.

Key words: Sensor Networks, Neonates, Pneumonia, Data Analytics, Prediction of Disease

1. Introduction. Digital disruption has been a major advancement in the medical field, which has led to the growth of disease identification and increased the efficiency of the workers in the sector. With the help of digital transformation within the healthcare departments, improvement of the experience of the patients has been enabled. Such an aspect not only increases the overall demand of such a sector, but also increases the trust and loyalty of the consumers [2]. Making greater discoveries and innovation of drugs through repeated trials and examining the results with the advanced hardware and software has been made feasible due to the inculcation of digital means into the healthcare sector.

The above mentioned figure illustrates the different kinds of tools and digital technology applied in the healthcare system to increase the overall efficiency of the industry [10]. Automation, big data, artificial intelligence, the Internet of Things, virtual reality, and telemedicine have been integrated into the sector to increase workflow and provide better communication between doctors and patients. Data analytics have played a vital role in predicting diseases at the early stages, which increases the overall potential of the medical procedure to aid the patients.

The vulnerability of newborns to a range of infections due to their underdeveloped immune systems is a pressing concern in the field of neonatal healthcare. The lack of immunity against various pathogens makes neonates susceptible to infections that can have severe consequences on their health and survival. Among these infections, pathogenic pneumonia in neonates stands out as a critical issue. Pathogenic pneumonia can arise shortly after birth or within the first week, leading to significant respiratory distress and potential fatality. This pressing challenge necessitates a deeper understanding of the clinical indicators and predictive measures that can aid in the early detection and management of pathogenic pneumonia.

The gravity of the situation calls for research efforts that not only delve into the clinical indicators of this infection but also explore innovative approaches to predict its occurrence. The integration of sensor networking and data analytics presents a promising avenue to enhance our understanding of the complex interplay of factors leading to pathogenic pneumonia in neonates. By leveraging technological advancements, researchers and healthcare professionals can potentially develop early detection systems that aid in timely intervention, thereby reducing the morbidity and mortality associated with this infection. The potential impact of such

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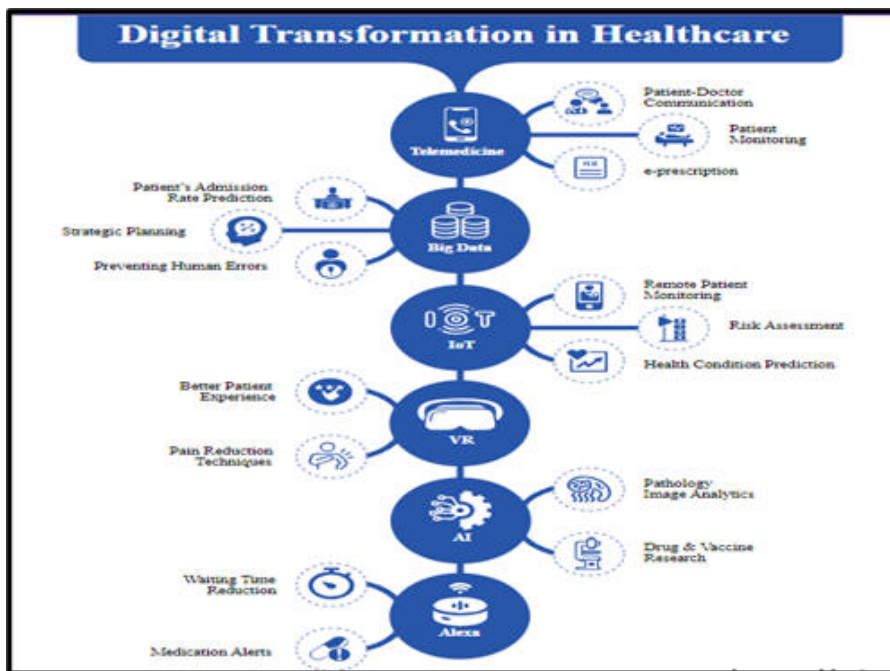Fig. 1.1: Different digital mediums used in healthcare

Fig. 2.1: Impact of digital transformation in healthcare

research is significant, as it addresses a critical gap in neonatal care and contributes to the well-being of the most vulnerable members of our population.

2. Objectives. The objectives which have been developed for the study are as follows:
1. To examine the occurrence of pathogenic pneumonia infection in neonates
2. To inspect the sensory networks developed through data analytics
3. To analyze pathogenic pneumonia prediction in newborns with sensor networking
4. To scrutinize the benefits which are achieved through early disease prediction with sensor networking

This work contributes to the field in several significant ways, showcasing both novelty and potential impact.
1. The research recognizes the transformative potential of digital mechanisms in healthcare systems, such as artificial intelligence, machine learning, and robotics. However, its unique contribution lies in expanding these digital advancements to the specific domain of neonatal healthcare. By applying sen-
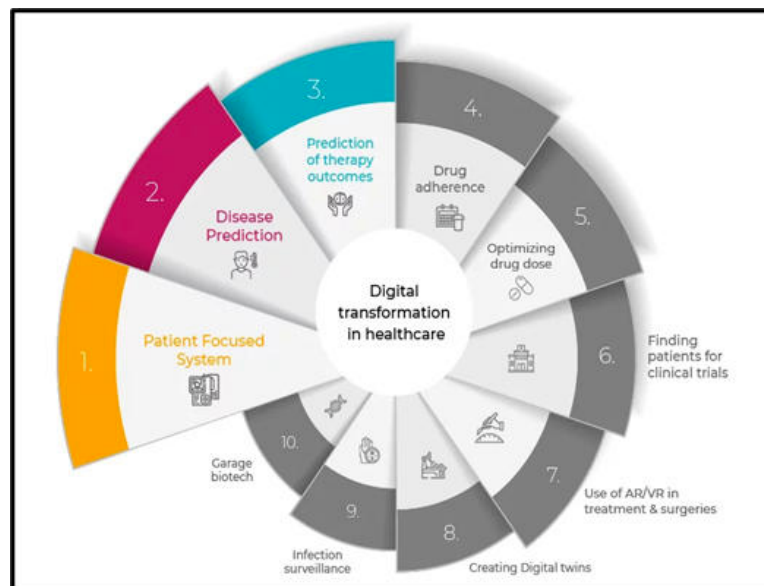
Fig. 3.1: Benefits of digital methods in medical system

    sor networking and data analytics to predict pathogenic pneumonia, the study advances the use of cutting-edge technology to address a critical healthcare challenge mainly affecting the most vulnerable population.

2. A noteworthy contribution of this work is its innovative approach to disease prediction in neonates. By utilizing past patient data, the study introduces a predictive model that aids in understanding disease progression and patterns. The novelty here is the application of such predictive modeling to neonatal infections, particularly pathogenic pneumonia. This can lead to early interventions, improving treatment outcomes, and reducing newborn mortality rates.

3. The research further extends its contribution by proposing the integration of sensor networks into the healthcare framework. This approach involves collecting real-time patient data through sensors, transmitting it to cloud-based systems, and leveraging data analytics for comprehensive interpretation. Applying this sensor-based approach tailored explicitly to neonatal pneumonia is novel and offers a novel perspective on disease management.

4. The study goes beyond conventional diagnostic methods by incorporating deep learning techniques. Integrating deep learning tools like DenseNet-121 for multimodal data analysis allows for a sophisticated and nuanced assessment of patient conditions. This represents a significant advancement in diagnostic capabilities, particularly in identifying the patterns associated with pathogenic pneumonia.

5. The research addresses a gap in neonatal healthcare by providing a tailored solution for predicting pathogenic pneumonia. Neonates have distinct healthcare needs, and this work recognizes that by designing a prediction model specific to their vulnerabilities. The proposed methodology could serve as a blueprint for other neonatal healthcare predictive models, further advancing the field of neonatology.

3. Methodology. A range of digital mechanisms have been integrated into the healthcare system, increasing the industry's overall efficiency. For instance artificial intelligence and machine learning help doctors to be provided with large amounts of analyzed data, which can recognize the patterns for improving the overall outcome of the healthcare system [4]. On the other hand, robotics and three-dimensional printing have also enabled the creation of prosthetics and implants, which can assist patients and doctors alike [5]. Optimisation of the workflow within the industry along with reduced expenses due to the inculcation of a larger number of healthcare workers, are produced as a result of digital transformation.
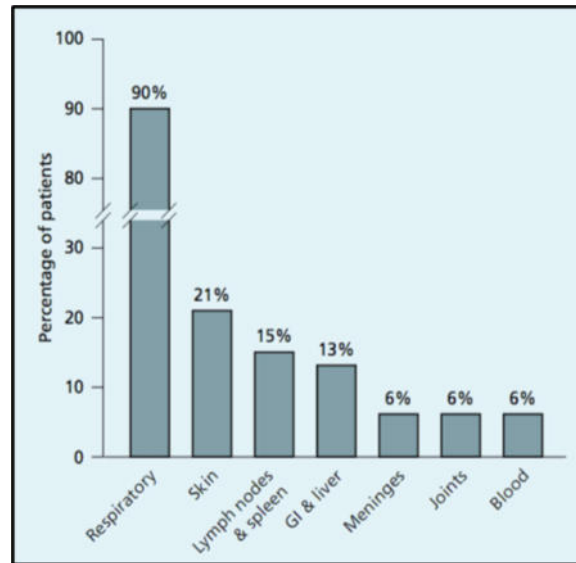
Fig. 4.1: Range of infections occurring in neonates

One of the vital advantages achieved with the inclusion of digital transformation is disease prediction through the assessment of past data from the patients [11]. By understanding the patterns and examination for the progression of the disease, data analytics has enabled researchers and doctors to gain a better understanding of the occurrence of the disorder within the patients. In such a manner, the alterations within the medical journey for the patients in terms of medicine and tests can be easily performed by the doctors, with the help of the interpreted data [3, 1].

4. Occurence of Pathogenic Pneumoniae Infection in Neonates. *Streptococcus pneumoniae* is the causative agent of pathogenic pneumonia in neonates. It has been regarded as one of the top pathogens that induce a high rate of mortality and morbidity in infants [30, 6]. The occurrence percentage of the disease has been found between 1% and 11%. However, the potential of mortality of the disease has been significantly high [7]. Two different variations of the diseases are noted to occur within the neonates, namely Early-onset pneumonia and Late-onset pneumonia. The latter group of disease is also termed ventilator-associated pneumonia because the induction of the disease is due to the elongated period of endotracheal intubation.

From the above figure, it can be assumed that respiratory diseases prove to be the highest-ranking disease sector that can impact the neonates. With about 90% of patient percentage, it is more than four times more likely to occur, than the second-ranking disease sector of skin infections [12]. The respiratory status of the patient drastically decreases with the increase in the longevity of the disorder, where respiratory secretions are observed.

The basic diagnosis of neonatal pneumonia occurs in the chest X-ray of the new needs along with the blood cultures and gram staining of tracheal aspirate. Tachypnea and chest recession also occurs in the patient, which gives a clear indication of the disease progression [8]. However, a range of issues have been identified in diagnosing neonatal pneumonia because of the lack of strict positive results. For instance, it has been recorded that the inspection by gram stain of tracheal aspirate is not an extremely prevalent test because of its decreased efficiency. It has been recorded that only about 2 to 5 percent of neonatal pneumonia cases can be identified with the help of such a test [13]. With the gram staining procedure, a lumbar puncture needs to be integrated with the medical diagnosis to increase the overall potential of the identification.

Such cumbersome procedures impact the health of the neonate because of the decreased immunity and body strength. For such reasons, disease prediction of the cases for such an age is extremely beneficial for decreasing the rate of mortality within the neonate [9].
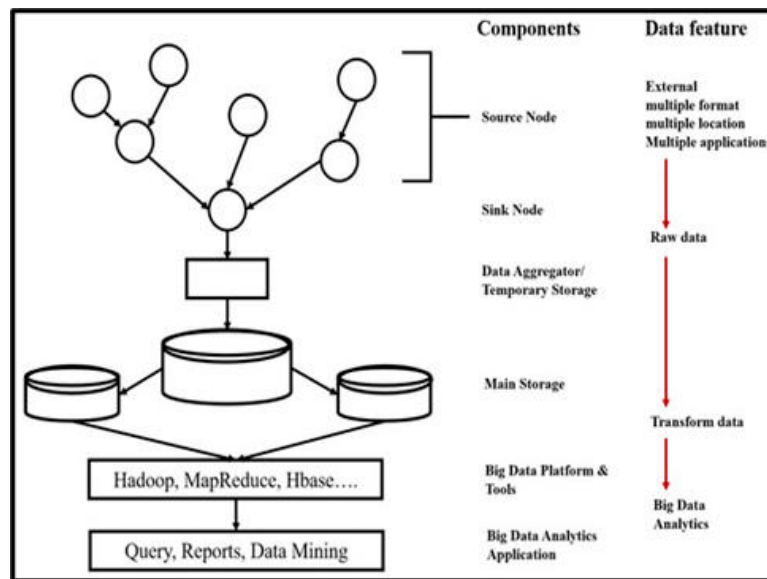
Fig. 5.1: Data transfer framework through the help of sensor data analytics

5. Sensor Networks Development through Data Analytics. Sensor data analytics is a sector of data analytics that aids in the interpretation of the past data for the generation of trends and patterns. Sensors are used for the collection of the data and information, which is sent to the cloud, for being computed and stored [14]. The analytical tool is used for the computation of the information and helps in the identification of the characteristics of the data. Through the help of such a medium, an in-depth assessment of the data can be achieved, which illustrates the linkage found between the aligning elements of the data [29].

As noted in the above image, a range of data systems are presented in data analytics for the transfer of information from one component to another. The sink node, present in the second layer of the data integration system, helps in the collection of the data from the sensor node [19]. The sensor node can obtain information from a range of sources and integrate it into the temporary storage or data aggregator present in the cloud. The manipulation of the aggregated data can be done with the help of the big data system which utilizes the chief storage for the alterations. The data which is hence transformed, are sent to big data platforms such as Hadoop and MapReduce. They find its application in the generation of queries and reports along with data mining activities.

6. Predicting Pathogenic Pneumoniae Infection in Newborns with Sensor Networks. IoT or the Internet of Things proves to be extremely necessary for the monitoring of information [31]. Through the application of data analytics, the analytical tools have the capacity of formatting and storing the data, as per the trends and patterns. Pinpointing of the different areas which can be improved with the help of data analytics can also be enabled. With the help of such a tool in healthcare, the assessment of the clinical data of the patients can be achieved. Uploading the data into the cloud server and the interpretation of the evidence can be achieved with the help of the data analytic system [24]. The software has the capacity to monitor the data against the occurring conditions, and optimise the evidence for accurate utilisation. In such a manner, the notions of asset utilisation can be achieved, where the segregated data can be interpreted by the doctors for reaching the desired outcome.

The detection strategies used for the diagnosis of pneumonia can be segregated broadly into two categories of machine learning based predictions and deep learning based classifications, as noted in the above figure 7.1 [17]. Edge computing environments have been seen to implement sensor data for increased decision making, in the healthcare system [20]. Through the collection of the signals with the help of the sensor, the information is passed onto the temporary and main storage. Network protocols such as Hypertext Transfer Protocol and
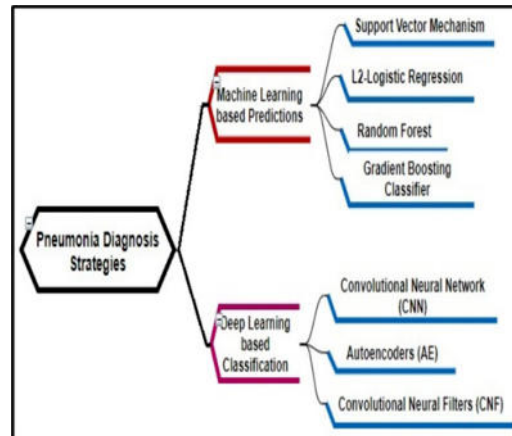
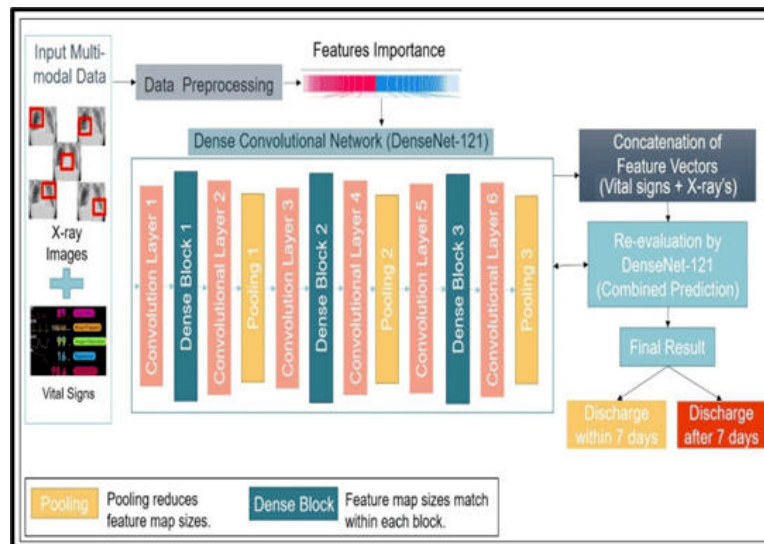Fig. 6.1: Schematic representation of the data analytics for diagnosis

Fig. 6.2: Data transfer cycle followed in data analytics for diagnosis

Constrained Application Protocol are utilised by the data sensors for the transfer of information, which enables in the sharing of the data of the patients. One of the most successful sensors which has been applied in the detection of neonatal pathogenic pneumonia is that of multimodal data analysis sensors [15].

Pathogen detection with the help of multimodal data analysis for neonatal pneumonia is achieved due to the usage of deep learning classification. In such a case, the signs and symptoms of the neonates are integrated into the sensor which classifies the status of health for the new net against the presented information. The improvement or the deterioration of the patient's condition can be made achievable with the help of the presented data where the disease prediction and the stage can be easily identified. This is enabled due to the prevalence of data analytics within the sensor system and helps in obtaining a highly accurate prediction of the outcome of the patient [25].

A range of image extraction can also be availed with the help of data analytics through the utilization of the technique of deep learning [32]. With the inclusion of a large amount of multimodal data in the form of X-rays and the vital signals of the patient, the various interpretations can be enabled with the help of data
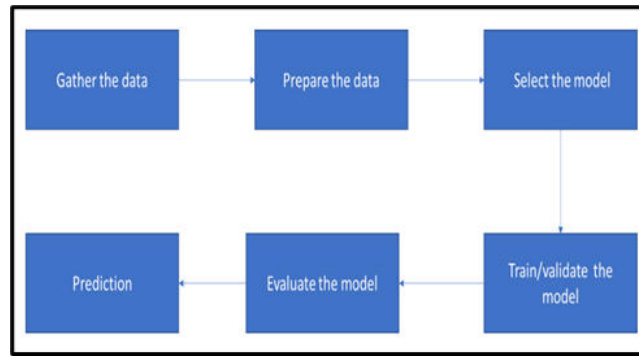
Fig. 7.1: Steps for solving of problems with data analytics

analytics through the process of data pre-processing. The key factors and the identification of the patterns can be integrated into the deer learning tool of DenseNet-121, which allows a lengthy interpretation of the data with the help of the dense layer architecture of the DenseNet-121 tool [21]. Such a digital medium provides the identification of the key patterns amongst the multimodal data and relates it with the vital signals of the neonates for examining the condition of pathogenic pneumonia infection within the patient.

7. Benefits of Early Disease Prediction with Sensor Networking. Sensor networking has been seen to provide an extensive edge in disease prediction [23]. Because of the fact that the whole system is automated, and the sensors pick up the digital information without any human intervention, the presence of human errors is absent. Such an aspect drastically increases the probability of reaching an error-free outcome that can be trusted by the doctors.

The advancement of tools and techniques for data analytics has allowed the doctors to achieve an early prediction, and with the auto-generated outcomes, the changing of the medical procedures for decreasing the mortality of the patients can be obtained [33]. Such a fact proves to be extremely desirable for increasing the overall experience of the patients and for inducing a greater chance of reaching the desired outcome [28].

8. Result. Artificial intelligence also enables the doctors to increase their evaluation frequency through the integration of data within the digital models and inducing data analytics for altering medication and method of assessment. Image processing and feature extraction of the X-rays and the symptoms respectively can be included into data analytics by the doctors for understanding the patterns within the new model infection and the alterations within the neonates, as per the stage of infection [16]. Several variables are identified using categorical grouping within the multimodal system and a range of tests such as univariate and multivariate regression can be performed with the data analytics system. Such an aspect is induced with the help of the pattern recognition and interpolation of the data within the data analytics system can be performed for algebraic operations [26]. The utilisation of computer vision operations can also be a major source of data for the sensors which helps the doctors to understand the exact condition of the stage of infection as per the results obtained by the tool performing data analytics.

As noted in the above figure, a large number of variables that are included within the data analytics are integrated for the correct interpretation of the characteristics of the neonates [22]. For instance, the age group of the patients is included within the data analytics for understanding the exact age bracket for the occurring symptoms. The extent of susceptibility of the new need to pneumonia infection is identified based on the age group of the parents, the presence of impact immunity, or the occurrence of chronic respiratory diseases. The prevalence of other infectious agents such as viruses and pathogens are also examined within the neonate to be included in the speed of data analytics. The clinical phenotype and the presence of causative pathogen for pneumonia, falling under the primary findings of the doctor are included along with the blood test reports [18]. Through the inculcation of such a range of data within the data analytic system, the doctors have the capacity to understand the extent to which the pathogenic pneumonia infection within the neonate can occur.
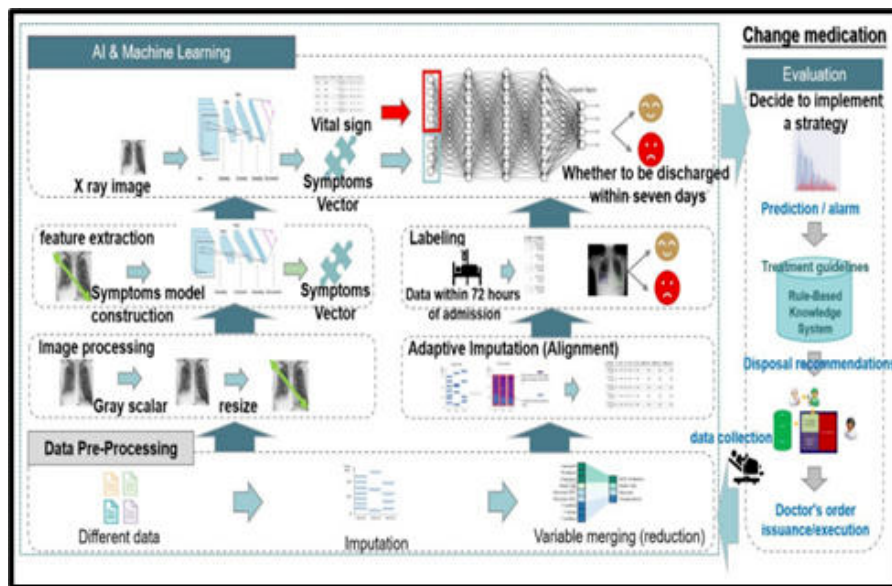
Fig. 8.1: Relationship between AI, Machine learning, and alliteration of medical procedures for the neonates

The usage of such variables which act as clinical indicators proves to be extremely necessary as the primary data being integrated acts as the basis upon which data analytics with the help of the sensors, would occur.

The ethnicity of the patients along with the presence of smokers in the household have been identified to have an impact on the probability of the neonate being born with pneumonia. On the other hand, the presence of impaired immunity and the prevalence of hospital-related respiratory diseases have also been identified to have a direct effect on the generation of neonatal pneumonia. Through the integration of such acute information within the sensor of data analytics, examination of the probability of the neonate being affected by pneumonia can be enabled. Such an aspect is recorded within the data analytics system to provide an in-depth examination of the occurrence of neonate pneumonia [27]. With the rise in the probability of the trends and patterns seen in the data, the changing of medications from an early hour can be enabled by the doctors.

The incorporation of the data such as the presence of influenza in larynx, the involvement of infection in the upper, the presence of causative pathogen for pneumonia in the pleural effusion, along with the blood test results examined in an extensive manner within the digital system for reaching a confirmed result. The integration of such data from the sensors of the data system enables the smooth computational flow of information and evidence to the data analytics system. With the occurrence of an in-depth interpretation of the aligning variables of the study, the doctors have the probability of understanding the presence or absence of neonatal pneumonia.

9. Problem Statement. One of the key limitations that has been identified in the article is the lack of financial information regarding the inclusion of sensor networking in the medical chains. Due to the fact that the induction of digital transformation withdraws a significant amount of finance from the facilities, the exact budget needed for setting up such a facility within the medical unit has not been jotted down in the study.

10. Conclusion. Hence, the study largely focused on the usage of digital transformation within the healthcare sector for achieving improved patient experience and helping in pathology image analytics. Risk assessment and remote patient monitoring by the reduction of human errors by doctors have also been identified to play major roles because of the integration of digital transformation within the healthcare sector. The inclusion of sensor data analytics for the prediction and confirmation of pathogenic pneumonia within newborns has been examined in an extensive manner. The utilization of clouds for the storage of data, the capturing of information with the help of sensors, and the provision of computer information as an output of data analytics have been

analyzed throughout the length of the study.

It's important to note that while sensor networking and data analytics offer valuable insights into predicting pathogenic pneumonia in neonates, the accuracy and reliability of such predictions may be influenced by factors such as the availability and quality of data, the diversity of pathogens, and the variability in individual neonatal responses to infections. Further research can explore the integration of advanced diagnostic techniques, such as genetic testing and rapid pathogen identification, to enhance the precision of predicting pathogenic pneumonia in neonates. Additionally, investigating the effectiveness of early intervention strategies based on the predictive models could contribute to reducing the impact of this life-threatening infection on newborns.

REFERENCES

[1] V. B, M. S, P. N, J. L, N. V, AND K. S, *Artificial conversational entity with regional language*, in 2022 International Conference on Computer Communication and Informatics (ICCCI), 2022, pp. 1–6.

[2] L. CADOT, H. BRUGUIÈRE, E. JUMAS-BILAK, M.-N. DIDELOT, A. MASNOU, G. DE BARRY, G. CAMBONIE, S. PARER, AND S. ROMANO-BERTRAND, *Extended spectrum beta-lactamase-producing klebsiella pneumoniae outbreak reveals incubators as pathogen reservoir in neonatal care center*, European Journal of Pediatrics, 178 (2019), pp. 505–513.

[3] D. DAI, H. CHEN, X. DONG, J. CHEN, M. MEI, Y. LU, L. YANG, B. WU, Y. CAO, J. WANG, ET AL., *Bronchopulmonary dysplasia predicted by developing a machine learning model of genetic and clinical information*, Frontiers in Genetics, 12 (2021), p. 689071.

[4] X. DONG, P. ZHOU, AND G. ZHU, *Common pathogens and drug resistance of neonatal pneumonia with new multichannel sensor*, Contrast Media & Molecular Imaging, 2022 (2022).

[5] P. FANG, K. GAO, J. YANG, T. LI, W. GONG, Q. SUN, AND Y. WANG, *Prevalence of multidrug-resistant pathogens causing neonatal early and late onset sepsis, a retrospective study from the tertiary referral children's hospital*, Infection and Drug Resistance, (2023), pp. 4213–4225.

[6] L. P. GARCIA, I. J. C. SCHNEIDER, C. DE OLIVEIRA, E. TRAEBERT, AND J. TRAEBERT, *What is the impact of national public expenditure and its allocation on neonatal and child mortality? a machine learning analysis*, BMC Public Health, 23 (2023), pp. 1–11.

[7] J. GLASER AND S. SHAW, *Digital transformation success: what can health care providers learn from other industries?*, NEJM Catalyst Innovations in Care Delivery, 3 (2022).

[8] G. GOPAL, C. SUTER-CRAZZOLARA, L. TOLDO, AND W. EBERHARDT, *Digital transformation in healthcare–architectures of present and future information technologies*, Clinical Chemistry and Laboratory Medicine (CCLM), 57 (2019), pp. 328–335.

[9] S. HERMES, T. RIASANOW, E. K. CLEMONS, M. BÖHM, AND H. KRCMAR, *The digital transformation of the healthcare industry: exploring the rise of emerging platform ecosystems and their influence on the role of patients*, Business Research, 13 (2020), pp. 1033–1069.

[10] S. A. G. KAABI AND H. K. MUSAFER, *An experimental mouse model for phage therapy of bacterial pathogens causing bacteremia*, Microbial Pathogenesis, 137 (2019), p. 103770.

[11] K. KLINKER, M. WIESCHE, AND H. KRCMAR, *Digital transformation in health care: Augmented reality for hands-free service innovation*, Information Systems Frontiers, 22 (2020), pp. 1419–1431.

[12] A. KOUROUBALI AND D. G. KATEHAKIS, *The new european interoperability framework as a facilitator of digital transformation for citizen empowerment*, Journal of biomedical informatics, 94 (2019), p. 103166.

[13] S. KRAUS, F. SCHIAVONE, A. PLUZHNIKOVA, AND A. C. INVERNIZZI, *Digital transformation in healthcare: Analyzing the current state-of-research*, Journal of Business Research, 123 (2021), pp. 557–567.

[14] N. KUMAR, G. AKANGIRE, B. SULLIVAN, K. FAIRCHILD, AND V. SAMPATH, *Continuous vital sign analysis for predicting and preventing neonatal diseases in the twenty-first century: big data to the forefront*, Pediatric research, 87 (2020), pp. 210–220.

[15] L. LE GUENNEC, M. COUREUIL, X. NASSIF, AND S. BOURDOULOUS, *Strategies used by bacterial pathogens to cross the blood–brain barrier*, Cellular microbiology, 22 (2020), p. e13132.

[16] Y.-C. LIU, H.-Y. CHENG, T.-H. CHANG, T.-W. HO, T.-C. LIU, T.-Y. YEN, C.-C. CHOU, L.-Y. CHANG, AND F. LAI, *Evaluation of the need for intensive care in children with pneumonia: machine learning approach*, JMIR Medical Informatics, 10 (2022), p. e28934.

[17] I. C. MARQUES AND J. J. FERREIRA, *Digital transformation in the area of health: systematic review of 45 years of evolution*, Health and Technology, 10 (2020), pp. 575–586.

[18] M. MASSARO, *Digital transformation in the healthcare sector through blockchain technology. insights from academic research and business developments*, Technovation, (2021), p. 102386.

[19] S. MATHUR, *Prediction and spatial interpretation of meteorological factors with neonatal mortality rate*, (2022).

[20] R. M. MCADAMS, R. KAUR, Y. SUN, H. BINDRA, S. J. CHO, AND H. SINGH, *Predicting clinical outcomes using artificial intelligence and machine learning in neonatal intensive care units: a systematic review*, Journal of Perinatology, 42 (2022), pp. 1561–1575.

[21] A. M. MOMANY, E. JASPER, K. E. MARKON, M. A. NIKOLAS, AND K. K. RYCKMAN, *Latent class analysis to characterize neonatal risk for neurodevelopmental differences*, Journal of Child Psychology and Psychiatry, 64 (2023), pp. 100–109.

[22] C. O'SULLIVAN, D. H.-T. TSAI, I. C.-Y. WU, E. BOSELLI, C. HUGHES, D. PADMANABHAN, AND Y. HSIA, *Machine learning*

applications on neonatal sepsis treatment: a scoping review, BMC Infectious Diseases, 23 (2023), pp. 1–10.

[23] K. Rassels and P. French, *Bio-remote sensing in predicting infection in neonates with thermal imaging and machine learning*, in 2022 Smart Systems Integration (SSI), IEEE, 2022, pp. 1–4.

[24] W. Ricciardi, P. Pita Barros, A. Bourek, W. Brouwer, T. Kelsey, and L. Lehtonen, *How to govern the digital transformation of health services*, European journal of public health, 29 (2019), pp. 7–12.

[25] N. Rixe, A. Frisch, Z. Wang, J. M. Martin, S. Suresh, T. A. Florin, and S. Ramgopal, *The development of a novel natural language processing tool to identify pediatric chest radiograph reports with pneumonia*, Frontiers in Digital Health, 5 (2023), p. 1104604.

[26] C. J. Saul, D. Y. Urey, and C. D. Taktakoglu, *Early diagnosis of pneumonia with deep learning*, arXiv preprint arXiv:1904.00937, (2019).

[27] R.-K. Sheu, L.-C. Chen, C.-L. Wu, M. S. Pardeshi, K.-C. Pai, C.-C. Huang, C.-Y. Chen, and W.-C. Chen, *Multi-modal data analysis for pneumonia status prediction using deep learning (mda-psp)*, Diagnostics, 12 (2022), p. 1706.

[28] K. M. Shuaib, S. A. Shahid, A. A. Javed, and M. Zaid, *Pneumonia detection through x-ray using deep learning*, IOSR Journal of Computer Engineering (IOSR-JCE), 22 (2020), pp. 08–11.

[29] J. C. Smith, A. Spann, A. B. McCoy, J. A. Johnson, D. H. Arnold, D. J. Williams, and A. O. Weitkamp, *Natural language processing and machine learning to enable clinical decision support for treatment of pediatric pneumonia*, in AMIA Annual Symposium Proceedings, vol. 2020, American Medical Informatics Association, 2020, p. 1130.

[30] B. Vivek, A. Arulmurugan, S. Maheswaran, S. Dhamodharan, A. S. Dharunash, and N. Gowtham, *Design and implementation of physical unclonable function in field programmable gate array*, in 2023 8th International Conference on Communication and Electronics Systems (ICCES), 2023, pp. 152–158.

[31] H.-C. Wang, C.-C. Liao, S.-M. Chu, M.-Y. Lai, H.-R. Huang, M.-C. Chiang, R.-H. Fu, J.-F. Hsu, and M.-H. Tsai, *Impacts of multidrug-resistant pathogens and inappropriate initial antibiotic therapy on the outcomes of neonates with ventilator-associated pneumonia*, Antibiotics, 9 (2020), p. 760.

[32] J. Wang, H. Zhang, J. Yan, and T. Zhang, *Literature review on the distribution characteristics and antimicrobial resistance of bacterial pathogens in neonatal sepsis*, The Journal of Maternal-Fetal & Neonatal Medicine, 35 (2022), pp. 861–870.

[33] Y. Wu, S. Mascaro, M. Bhuiyan, P. Fathima, A. O. Mace, M. P. Nicol, P. C. Richmond, L.-A. Kirkham, M. Dymock, D. A. Foley, et al., *Predicting the causative pathogen among children with pneumonia using a causal bayesian network*, PLoS Computational Biology, 19 (2023), p. e1010967.