Dissertation

At

Wadhwani AI

By

"Early Identification and detection of Sepsis using AI/ML based Algorithm - A literature review"

Name: **SARANSH KHANNA**
Enroll No: **PG/21/091**

Under the guidance of

Dr. SUKESH BHARDWAJ
ASSOCIATE PROFESSOR
(HEALTH IT)

PGDM (Hospital and Healthcare Management)
2021-2023

International Institute of Health Management Research

New Delhi

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Completion of Dissertation

The certificate is awarded to

Name: Saransh Khanna

In recognition of having successfully completed his dissertation at 'Wadhwani AI'

He has successfully completed his project on

"Early Identification and detection of Sepsis using AI/ML based Algorithm - A literature review"

Date of submission: **17 May 2023**

Organisation - "**Wadhwani AI**"

He comes across as a committed, sincere & diligent person who has a strong drive & zeal for learning.

We wish him/her all the best for future endeavors.

Shreya Thakur
Solution Manager
Wadhwani AI

Certificate from Dissertation Advisory Committee

This is to certify that **Mr. Saransh Khanna**, a graduate student of the **PGDM (Hospital & Health Management)** has worked under our guidance and supervision. He is submitting this dissertation titled "Early identification and detection of Sepsis using AI/ML based Algorithm- A literature review" at "Wadhwani AI" in partial fulfillment of the requirements for the award of the **PGDM (Hospital & Health Management).**

This dissertation has the requisite standard and to the best of our knowledge no part of it has been reproduced from any other dissertation, monograph, report or book.

Institute Mentor Name, Dr. Sukesh Bhardwaj
Designation, Associate Professor

Organization IIHMR, Delhi

Organization Mentor Name Shreya Thakur
Designation, Solution Manager

Organization Wadhwani AI.

Certificate of Approval

The following dissertation titled **"Early identification and detection of Sepsis using AI/ML based Algorithm- A literature review" at "Wadhwani AI"** is hereby approved as a certified study in management carried out and presented in a manner satisfactory to warrant its acceptance as a prerequisite for the award of **PGDM (Hospital & Health Management)** for which it has been submitted. It is understood that by this approval the undersigned do not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein but approve the dissertation only for the purpose it is submitted.

Dissertation Examination Committee for evaluation of the dissertation.

Name	Signature
PRAVEEN KUMAR.	
VINAY TRIPATHI	
HIMANSHU TOLANI	

Annexure F

FEEDBACK FORM

Name of the Student: SARANSH KHANNA

Name of the Organisation in Which Dissertation Has Been Completed: NADHNANI AI

Area of Dissertation: EARLY WARNING SYSTEM FOR SEPSIS and prognosis AI in ASSISTIVE TECHNOLOGIES

Attendance: 100%

Objectives achieved: YES

Deliverables: Saransh was diligent in submitting his deliverables and his approach and research skills were commendable

Strengths: Business analysis, user research, research studies, public health & healthcare

Suggestions for Improvement:
Solutions designing

Suggestions for Institute (course curriculum, industry interaction, placement, alumni):
IIHMR is doing great, students have demonstrated professionalism and aptitude to adapt & learn

Signature of the Officer-in-Charge/ Organisation Mentor (Dissertation)

14th June 2023

Date: Delhi
Place:

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Saransh Khanna student of PGDM (Hospital & Health Management) from International Institute of Health Management Research, New Delhi has undergone internship training at “Wadhwani AI” from 06/02/23 to 05/05/23.

The Candidate has successfully carried out the study designated to him during internship training and his/her approach to the study has been sincere, scientific and analytical.

The Internship is in fulfilment of the course requirements.

I wish him all success in all his future endeavors.

Dr. Sumesh Kumar
Associate Dean, Academic and Student Affairs
IIHMR, New Delhi

Mentor

IIHMR, New Delhi

INTERNATIONAL INSTITUTE OF HEALTH MANAGEMENT RESEARCH, NEW DELHI

CERTIFICATE BY SCHOLAR

This is to certify that the dissertation titled "Early identification and detection of Sepsis using AI/ML algorithm- A literature review" and submitted by Saransh Khanna. Enrollment No. – PG/21/091 under the supervision of Dr. Sukesh Bhardwaj for award of PGDM (Hospital & Health Management) of the Institute carried out during the period from 2021 to 2023 embodies my original work and has not formed the basis for the award of any degree, diploma associate ship, fellowship, titles in this or any other Institute or other similar institution of higher learning.

Signature

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Name of Student (in block letter)	Dr./~~Mr.~~/Ms.: SARANSH KHANNA		
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Course Specialization (Choose one)	Hospital Management	Health Management	Healthcare IT
Name of Guide/Supervisor	Dr./ Prof.: Dr. Sukesh Bhardwaj		
Title of the Summer Training/ Dissertation	"Early Identification and detection of Sepsis using AI/ML based Algorithm - A literature Review."		
Plagiarism detect software used	"TURNITIN"		
Similar contents acceptable (%)	Up to 15 Percent as per policy		
Total words and % of similar contents Identified	8%		
Date of validation (DD/MM/YYYY)	01/06/2023		

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Institute Librarian

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Date:

Library Seal

Dean (Academics and Student Affairs)

Signature:

Date:

(Seal)

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ABOUT THE ORGANISATION: Wadhwani AI

Wadhwani AI, is an independent, non-profit institute. Founded in 2018, it is dedicated to developing Artificial Intelligence solutions for social good. Their mission is to build AI-based innovations and solutions for underserved communities in developing countries, for a wide range of domains including agriculture, education, financial inclusion, healthcare, and infrastructure.

We aim to harness the power of AI to find the break points that cause the world's deepest problems — and then find innovative solutions to fix them. We specialize in AI research to address problems in public health, agriculture, education and infrastructure using tools such as Machine Learning, Data Science, Cognitive Reasoning and IoT.

We are a global AI hub with ongoing collaborations with leading academic organisations, global non-profits, think tanks and other private foundations who are interested in leveraging AI as a force for social good.

We partner with government agencies, and non-governmental organizations to help identify needs and to implement and scale the solutions. Our core aims include: - Conduct ground-breaking applied AI research - Pilot solutions on-ground in collaboration with the affected communities - Deploy solutions at scale in collaboration with the social sector and civic authorities.

The Wadhwani Institute for Artificial Intelligence was formed to build and deploy AI solutions that benefit underserved populations in developing countries, which it has actively been doing since mid-2021. We partner with government bodies and global non-profits to ensure that our innovations will improve the lives of those who need them the most.

Currently we are building AI-based solutions in the agriculture and health domains, such as pest management for cotton farms, maternal, new-born and child health, tuberculosis and COVID19.

Our Current Solutions:

Pest Management

Our solution is being developed to help reduce crop losses through integrated pest management in cotton farms.

Tuberculosis

We are creating technologies towards:

Automated reading of TB LPA test results.

Providing differentiated interventions for TB patients by applying critical resources appropriately. We predict a score for patients most likely to prospectively not adhere to the treatment regimen, when they come in for their first treatment.

Newborn Anthropometry

We are creating a smartphone-based anthropometry technology, which will allow frontline workers to track baby weight in rural homes and hospital settings.

COVID-19

We provided epidemiological forecasting for COVID-19 to assist in resource planning. We also conducted research to identify signature patterns for COVID-19 using cough sounds.

Vision

Systems that are sustainable and scalable can transform the lives of billions of people. We believe that using AI to solve problems at the bottom of the pyramid can lead to a better, more equitable world for all.

"We are in an age where efforts to achieve the UN Sustainable Development Goals are accompanied by a revolutionary explosion of digitally available data and the penetration of internet-enabled smartphones into previously inaccessible rural locales. AI technology is the natural tool for leveraging this vast scaleup in the quantity and breadth of data into actionable machine learning models that direct on-the-ground interventions for underserved populations. "It is expected that while we are in the midst of this accelerated growth, data sources will be unstable, incomplete, and erroneous, presenting a key challenge in developing AI models. At the other end of the tech pipeline, AI solutions should be designed to facilitate delivery to the last mile user without significantly perturbing existing public systems."

Approach

Effective solutions start with a systematic, long-term commitment to use AI for good. This involves working closely with partner organizations to create a conducive environment for defining problem areas, and developing and implementing solutions – a process we define as 'AI-readiness'.

Radical Collaboration

We partner with governments, social sector organisations, domain experts and academic institutions to ensure our innovations are accessible to those who need them the most. Our work is funded by technology entrepreneurs and philanthropists Romesh and Sunil Wadhwani,, Bill and Melinda Gates Foundation, Google.org, USAID, and Foundation Botnar. We work closely with a range of global and Indian organisations to effectively deploy our solutions.

Strategic Programs

We have been supporting various ministries and policy think tanks at the Indian state and Central government level – including NITI Aayog, Ministry of Health & Welfare, state governments of Telangana, Maharashtra and more – to identify use cases, collect data, conduct pilots and deploy solutions through our Strategic Programs initiative.

AI-Readiness

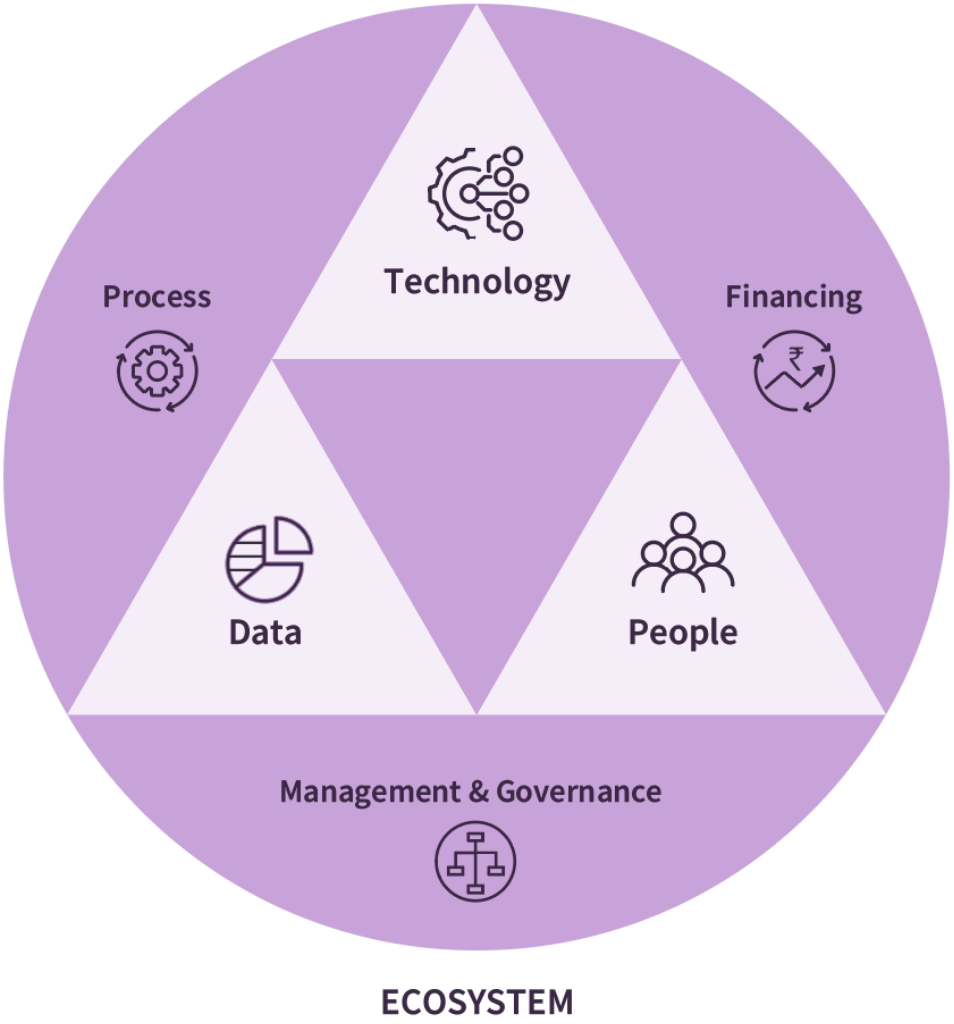
This refers to a partner organization's ability to create and use AI solutions to achieve certain benefits.

Ability: The capacity to engage in AI problem definition and to support AI solutions sustainably.

Create: Once a specific problem is defined, the actions (including technologies and methods) that may be used to build AI solutions.

Use: Activities involved in effective application of the solutions

Benefits: Anticipated benefits at the beginning of the project should match benefits accrued once it is implemented. It includes course correction and actions to modify a partner's Ability.



We have identified the key filters to measure the AI-readiness of an organisation or a specific project.

For our partners, AI-readiness provides a link between long-term activities to be performed at the organization-level and precise benefits accruing from the implementation of AI in specific projects.

BACKGROUND:

Sepsis is a "life-threatening organ dysfunction that is caused by a dysregulated host response to infection," It is a challenge for the world's health. The window of opportunity for making a clinical diagnosis of sepsis is quite small, and it calls for prompt treatment "as soon as possible." (1) It is the top cause of death in both developing and developed nations, as well as the major cause of hospital deaths, and survivors are more likely to suffer from chronic illnesses, organ failure, or neurological damage. (16)

According to the World Health Organization (WHO), anyone who has an infection can develop sepsis, but some groups of people are at a higher risk of developing this condition. These high-risk groups include hospitalized patients, neonates, pregnant women, the elderly, immunosuppressed people, and patients with chronic diseases. Hospitalized patients are more susceptible to getting sepsis due to the invasive procedures and medical devices that they may be exposed to Neonates, or newborn infants, have an immature immune system, which makes them more susceptible to infections that can lead to sepsis. Expecting mothers are also increased risk of sepsis because of immune system alterations during pregnancy. (2)

The elderly population is more susceptible to infections due to a reduced immune system and other chronic medical conditions. Immunosuppressed people, such as those with HIV/AIDS or undergoing cancer treatment, have a compromised immune system and are therefore more susceptible to infections, which can lead to sepsis. (15)

Patients with chronic diseases, such as diabetes, heart disease, and lung disease, are also at a higher risk of developing sepsis due to their weakened immune system and increased susceptibility to infections. (2)

Given that sepsis care is extremely time sensitive, early sepsis prediction is essential to prevent mortality. According to international medical recommendations, early fluid resuscitation should commence within the first three hours to stabilize sepsis-induced tissue hypoperfusion. Intravenous antibiotic therapy should start as soon as possible, ideally within an hour of the onset of sepsis. (15)

Despite its severity, the epidemiology of sepsis is poorly understood. It is alarming to note that 1 in 5 deaths worldwide is related to sepsis. Unlike other diseases, there is not a single bacteria or virus that causes sepsis. Instead, it can result from any type of pathogenic infection. (!)

The problem of sepsis is further compounded by the elevated level of antimicrobial resistance. Antimicrobial resistance is a serious health issue in India, and it plays a significant role in the development and spread of sepsis. Superbugs that are resistant to several different antibiotics have emerged as a result of the overuse and abuse of antibiotics. As a result, infections that lead to sepsis are challenging to treat. (16)

The associated cost of treatment may widely vary but is consistently extremely expensive. (5)

In 2017, India estimated that there were 11 million cases of sepsis identified. It was also reported that there were nearly 3 million deaths as a result. A study performed by the Journal of perinatology revealed that sepsis, meningitis, and tetanus contribute to 16.4% of all neonatal deaths in India. Moreover, in India, 34% of sepsis patients die while their stay in the Intensive Care Unit (ICU). These numbers highlight the severity of sepsis and its impact on the population in India. It's critical to recognise the symptoms of sepsis and take the necessary precautions to stop it's spread. Understanding causes and effects of sepsis is crucial in combating this disease and improving overall health outcomes in India. (3)

A prospective cohort research including multiple sites was done to assess the effectiveness of Targeted Real time Early Warning System (TREWS) in identifying sepsis patients early and improving patient outcomes. The study was carried out across five hospitals in Maryland and Washington, DC. The study's conclusions show that TREWS and other early warning systems have the ability to detect sepsis patients quickly and improve patient outcomes. This work adds to the growing body of research that shows early warning systems can be used to detect and treat sepsis early on. These results are particularly important given the high mortality rate associated with sepsis, and the need for early intervention to improve patient outcomes. (4)

Overall, the study highlights the potential benefits of deploying early warning systems in healthcare settings to improve patient care and outcomes. In comparison to patients whose alert was not confirmed within 3 hours, those whose alert was confirmed within 3 hours had a lower rate of in-hospital death, organ failure, and duration of stay. (4)

However, recent advances in artificial intelligence and machine learning have shown promising results in early detection and intervention of sepsis. By analyzing physiological parameters such as heart rate, blood pressure, and oxygen levels, an AI/ML-based model can track changes that may indicate the onset of sepsis before it becomes clinically apparent. (4)

Early recognition of sepsis is crucial for effective intervention and improved outcomes. Research has shown that Every hour of treatment delay raises the likelihood of death by up to 8%. Therefore, by providing earlier and more effective intervention, AI/ML-based models have the potential to reduce the incidence, prevalence, and mortality from sepsis. (4)

This literature review could help to identify the available models developed and their utility in India and globally which can be used by other researchers in evaluating and developing robust AI/ML algorithms for early prediction of sepsis in the future.

Keywords:

Sepsis, Artificial Intelligence, Machine Learning, AI/ML, and Mortality.

Objectives/Key Research Questions:

Primary objective:

- The primary aim of the study is to map current landscape and the stage of the utility of AI/ML-based models for the early prediction and identification of sepsis.

Secondary objective:

- Understanding various variables used for the identification of sepsis according to studies available.
- Understanding the various AI/ML algorithms used for the identification of sepsis according to studies available.

Methodology:

- ## Study design:

  Secondary research

- ## Eligibility criteria:

  The review is performed using a comprehensive literature collection using databases/ search engines such as PubMed, Web of Science, and Google Scholar that is compiled to answer our research questions.

- ## Types of studies:

  We included primary studies, review papers, cross-sectional studies, cohorts, and Randomized Controlled trials (RCTs). We included full text or abstract only and studies with full text in English in our study. Criteria regarding time and language was implemented as all the research studies that has been published between January 2010 and December 2022 are considered and studies having language other than English are not considered for our study.

- ## Types of participants:

  People having a high risk of developing sepsis such as hospitalized patients, neonates, pregnant women, the elderly, immunosuppressed people, and patients with chronic diseases are included.

- ## Types of Intervention:

  Use of AI/ML-based tools for early prediction of sepsis in any tertiary care hospital, medical college, or healthcare center.

RESULTS:

In the area of artificial intelligence known as machine learning, algorithms are used to analyse and learn from vast volumes of data, and then use that learning to make predictions and decisions about future events. Machine learning (ML) algorithms are created to learn from data, and they may adapt and get better over time, in contrast to traditional software programmes, which are hard programmed to carry out specific tasks. (7)

The most basic method of machine learning is called supervised learning, which involves training an algorithm on a set of labeled data, and then using that training to make predictions about new, unlabelled data. This method is utilised frequently in programmes like speech recognition, image recognition, and natural language processing. (9)

Another common method of ML is unsupervised learning, which involves analyzing a dataset without any pre-existing labels or categories. This method is often used in clustering and anomaly detection applications, where the primary goal is to identify different patterns or trends in the data.

ML has become very important in recent few years, as the volume of data produced by corporations and organisations has increased dramatically. By using machine learning algorithms to analyze this data, organizations can gain insights and make better decisions about their operations and customers. It has been a fundamental aspect of AI development since its inception. In the initial stages, several algorithms were developed, including decision trees, support vector machines, clustering, and more. These algorithms have been used to help machines learn through various techniques. There are several different learning techniques that are used to categorize machine learning. These methods consist of reinforcement learning, semi-supervised learning, unsupervised learning, and supervised learning. (9)

Supervised learning, unsupervised learning, & semi-supervised learning are all example of the first model used in machine learning. These algorithms have been extensively used in the field of study and have proven effective. Later, further algorithms were created to enhance the performance of ML. One such algorithm is integrated learning, which is a combination of multiple learning algorithms. Integrated learning uses different models to predict the output of a given input, and the final output is decided by combining the predictions of these models. This approach has been observed to produce better results than individual models. (8)

Another advanced algorithm is deep learning, which involves a complex neural network that can learn from enormous data. Natural language processing, picture and speech recognition, and many more applications all require deep learning. (8)

Reinforcement learning is an algorithm that enables an agent to learn from its environment by receiving rewards or punishments. Reinforcement learning is commonly used to develop autonomous agents in robotics, games, and decision-making systems. (9)

In conclusion, other algorithms were developed to improve the performance of machine learning, even if supervised learning, unsupervised learning, and semi-supervised learning were the first ones utilised. These consist of reinforcement learning, deep learning, and integrated learning.

Use of AI in early identification and detection of Sepsis:

Sepsis is a life-threatening medical condition that is caused by the body's response to an infection. It is a severe condition that may result in organ failure and death. According to the Canters for Disease Control and Prevention (CDC), sepsis is one of the leading causes of death in individuals with serious illnesses. Despite recent advances in medical technology, morbidity and mortality rates remain high, primarily due to the failure to follow clinical recommendations and the delay in initiating treatment.

Artificial Intelligence (AI) has brought forth the potential to revolutionize the early identification and detection of sepsis. AI algorithms can analyse huge amount of clinical data from electronic health records systems (EHR), vital signs monitors, & other sources to detect patients who are more prone to sepsis. These algorithms can also detect patients who have already developed sepsis, even before clinical symptoms are apparent. (14)

AI-powered systems can alert clinicians about patients who are at more prone to sepsis, enabling early intervention and treatment. These systems can also help clinicians to monitor patients who are already receiving treatment for sepsis, allowing for more timely adjustments to treatment plans. Here is the list of variables which can be used such a solution.

Table 1. Shows the variables used for true value of sepsis detection:

S.No.	Category	Variables of Importance
1.	Physiological features	• Heart Rate • Respiration Rate • Temperature • Blood Pressure • Mean Blood Pressure • Skin Color • Nail Bed • Mental State • Blood Glucose/Diabetes • Positive fluid balance • Spo2/Hypoxemia • Urine Output • Apnea • Catheter Insertion • PaCo2, Pao2, & Fio2 • Pao2/Fio2 Ratio • Central Venous Line • Arterial Line • Mechanical Ventilation • Intubated-free days • Inotrope-free days • Antibiotics use • ECMO use • Length of stay (Hours)

2.	Lab findings	• Mean CCI (Charlson Comorbidity Index) • RDW (Red blood Cell Volume Width) • BUN (Blood Urea Nitrogen) • Arterial Lactate/Serum Lactate • Creatinine • PLT (Platelet) • WBC (White Blood Cell) • C-reactive Protein • Bilirubin Levels • Blood Culture • Albumin • Arterial PH • Calcium/Ionized Calcium • Hemoglobin • Magnesium • PTT (Partial Thromboplastin Time) • Potassium • SGPT (Serum Glutamic-Pyruvic Transaminase) • SGOT (Serum Glutamic-Oxaloacetic Transaminase) • Chloride • Bicarbonate • Sodium • Co2 Levels • PT (Prothrombin Time) • Urea • ABG (Arterial Blood Gas) • Leukocytes • Neutrophils % • Basophils % • Band Cell Number and % • D-dinner • Eosinophils • Lymphocytes • Cholinesterase • LDL (Low density Lipoprotein) • LDH (Lactate Dehydrogenase) • TBIL (Total Cholesterol)
3.	History	• Dementia • Neurological Sequelae • Malignancy/Malignant Cancer • Metastatic Solid Tumor Cancer • Renal Disorder • Chronic Obstructive Pulmonary Disorder • Congestive Heart Failure/Disease • Acute Liver Disease • Gastrointestinal Disorder/Bleeding • Bronchopulmonary Dysplasia • Cholestasis • Comorbidity Necrotizing Enterocolitis • Comorbidity with IVH or Shunt

		• Comorbidity with Lung Disease • Elix Hauser
4.	Demographic details	• UHID/PID • Age (Days/Months/Year) • Gender • Weight (Kg) • Race • Timestamp

In addition to early detection, as a result of a patient's specific medical history and other considerations, AI can also assist in personalising treatment recommendations which can further lead to improved outcomes and reduce in the mortality rates from such a fatal disease. (14)

Overall, the use of AI for early prediction, identification and detection of sepsis has the potential to save lives of lot of people and improving the quality of care provided to the patients. As research continues in this area, we can expect to see even more advances in the field of sepsis detection and treatment. (14)

The field of medicine has been rapidly evolving with the integration of artificial intelligence (AI) technology. The creation of clinical decision support systems (CDSS) is one area where AI has shown a lot of promise. These tools have been created to help healthcare professionals make better choices regarding patient care. (14)

In recent years, AI has been applied to the study of sepsis, a potentially life-threatening condition. AI has been utilized at various stages of sepsis detection or prediction, prognosis from such a disease & its evaluation, and also mortality or death prediction.

A lot of studies have demonstrated the effectiveness of AI in identification of sepsis in patients before symptoms become apparent. By analyzing patient data, which includes live data from EHR systems having data such as vital signs, laboratory findings, and medical/family history, AI algorithms have been developed that predict the onset of sepsis with high accuracy even before onset of it.

AI has also been used to check the prognosis and changes in physical conditions of sepsis patients. By analyzing patient data, AI algorithms can identify factors that may contribute to a poor prognosis and provide healthcare providers with actionable insights to improve patient outcomes.

Table 2. Summary of the results from the related works on the prediction of sepsis.

Authorship	**Year**	**Variables Used**	**Techniques**	**Algorithms**	**AUROC**
Misra et al.	2021	15	Apache Spark Random under-sampling algorithm	Random forest	0.9483
Wardi et al.	2021	40	Transfer learning A modified Weibull-Cox proportional hazards model	AI Sepsis Expert	0.833
Wickramartane et al.	2020	36	Recurrent Neural Network Variant	Bi-Directional Gated Recurrent Units	0.97
Lee et al.	2020	40	Deep learning-based early warning system	Graph Convolutional Network	0.782
Kok et al.	2020	40	Gaussian Process Regression	Temporal Convolution Network	0.98
Bedoya et al.	2020	86	Internal & Temporal validation	Muti-output Gaussian	0.88
Lauritsen et al.	2020	30	Multi-layer feedforward neural network	Convolutional Neural Network & Long Short-term Memory Network	0.856
Mohammed at al.	2020	5	Physiological data streams	Support vector machine	0.781
Cooper et al.	2020	6	Logistic regression	Automated Sepsis screening tool	0.857
Helguera Repetto et al.	2020	25	Internal validation	Artificial Neural Network	0.944
Kaji et al.	2020	119	A TensorFlow backend	Long Short-Term Memory Recurrent Neural Network	0.876
Yuan et al.	2020	106	A decision tree-based algorithm	XG Boost	0.89
Bloch et al.	2019	4	10-fold cross validation	Support vector machine	0.8838
Scharpf et al.	2019	10	4-fold stratified-cross-validation	Recurrent Neural Network	0.81
Liu et al.	2019	128	Natural Language Processing features	XG Boost	0.92

The SVM classifiers model by Mohammed at al can predict sepsis, with an average detection accuracy of 83.0% and an Area Under Receiving Operator Characteristics (AUROC) of 0.781 which is the minimal AI model developed for early prediction of sepsis. [10]

Logistic regression is also used to measure six variables related to sepsis, and a predictive model (automated screening tool) with an AUROC of 0.857 has been developed to help identify patients at risk of sepsis. The screening tool can screen all hospitalized patients and pass the results directly to caregivers without any manual intervention. [11]

Bi-Directional Gated Recurrent Units (GRU) is a deep learning algorithm that uses various parameters related to vitals, laboratory, and demographics. [12]

The AUROC of this model is 0.97, which can predict the occurrence of sepsis 6 h in advance. This method is better than the AI models for sepsis prediction found in the current literature. There is also an early warning system for sepsis using deep learning. [13]

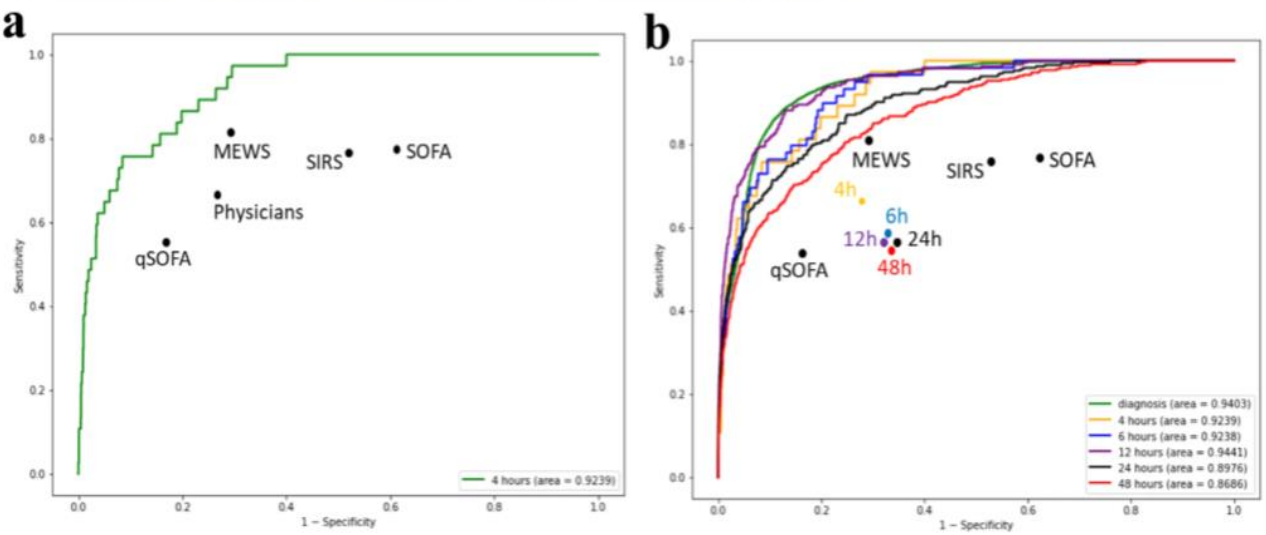
Another sepsis detection system uses a convolutional neural network and a long short-term memory network. The quality evaluation of the model is based on standard concepts of accuracy and clinical applicability, and the intervention is evaluated retrospectively by observing intravenous antibiotics and blood cultures before the predicted time. The AUROC at 3 h before the onset of sepsis was 0.856. In the past, due to the delay in sepsis recognition, the vast majority of sepsis patients did not start antibiotic treatment or blood culture in time. Therefore, such a model can promptly facilitate clinical interventions through early identification.

In addition to the above-mentioned deep learning, some people have developed an explainable AI model for early prediction of sepsis. They developed a model based on shared ICU public data and verified the challenge score in a completely hidden population. [14]

The explainable AI model extracts 168 features per hour and is trained to achieve real-time prediction of sepsis. The influence of each feature on the real-time prediction of sepsis is discussed in depth to show its interpretability. This model not only has superior performance in estimating the risk of sepsis in real time, but also provides interpretable information for comprehending the risk of sepsis.

Prediction AI Vs Human Prediction:

From: Artificial intelligence in sepsis early prediction and diagnosis using unstructured data in healthcare



a, **b** The ROCs represent the performance of early prediction algorithm at 4, 6, 12, 24, and 48 h prior to the onset of sepsis using the independent, test sample. "qSOFA", "MEWS", "SIRS", and "SOFA" represent the TPR and FPR from these methods employed by physicians in prior studies at 0–4 h prior to the onset of sepsis. "Physicians" represent TPR and FPR of patients in the independent, test sample set that were suspected by hospital's physicians to have sepsis at 4 h prior to the onset of sepsis. **b** "4 h", "6 h", "12 h", "24 h", and "48 h" represent TPR and FPR of patients in the independent, test sample set that were suspected by hospital's physicians to have sepsis at the respective time prior to the onset of sepsis.

Finally, AI has been applied to the prediction of mortality in sepsis patients. By analyzing patient data, including clinical and laboratory values, AI algorithms can accurately predict the likelihood of patient mortality.

In conclusion, AI has shown significant promise in the study of sepsis and its application in the development of CDSS systems and as technology continues to advance in the coming future, it is likely possible that AI will continue to play an increasingly important role in the field of medicine and other fields as well.

A recent study compared the performance of how SERA algorithm which was a ML algorithm was compared with human prediction for early prediction of sepsis at various time intervals prior to onset. The study used unstructured data from healthcare settings to evaluate the accuracy of both AI and human prediction.

The results of the study were promising, with the SERA algorithm outperforming human prediction in some cases. Specifically, the algorithm was more accurate at predicting sepsis at 4, 6, and 12 hours prior to onset. At 24 and 48 hours prior to onset, human prediction was still slightly more accurate than the SERA algorithm.

The early prediction algorithm's ROC curves were plotted and compared against the commonly utilized standardized scoring systems such as systemic inflammatory response syndrome (SIRS), sequential organ failure assessment (SOFA), quick SOFA (q SOFA), and modified early warning

system (MEWS) scores. The results of the analysis revealed that the SERA algorithm completely outperformed the typically reported accuracy rate of these scoring systems.

The ROC curves are graphical representations that illustrate the performance of the algorithm in predicting outcomes. The SERA algorithm's ROC curve was found to have a higher area under the curve (AUC) compared to the other scoring systems. The AUC is a method to measure the accuracy or algorithm's ability to correctly distinguish between the outcomes as positive and negative which are the output by the ML model.

Study's findings suggest that the SERA algorithm can be a more reliable tool for early prediction of clinical outcomes. The algorithm's superior performance can help clinicians make more accurate and timely decisions, leading to improved patient outcomes.

CONCLUSION:

In conclusion, the analysis of the plotted ROC curves revealed that the SERA algorithm outperformed the commonly utilized standardized scoring systems such as SIRS, SOFA, q SOFA, and MEWS scores in predicting clinical outcomes. The study's findings suggest that the SERA algorithm can be a more effective tool for clinicians in predicting outcomes and making timely and accurate decisions.

Sepsis is a serious medical condition that can have devastating consequences for patients. This phenomenon occurs when an infection disrupts the body's normal response, causing a dangerous imbalance. Unfortunately, sepsis has a high mortality rate and can cause significant organ damage that may be fatal.

In addition to the impact on human health, sepsis also places a major financial burden on medical and healthcare systems. The relative cost of treating patients with such a disease can be substantial, and the long-term consequences of the condition can be expensive to manage which might result in catastrophic health expenditure and further burden on the individual.

Given the severity of sepsis and its impact on patients and healthcare systems, it is essential that medical professionals and policymakers work to raise awareness of the condition and invest in research to develop more effective treatments. By addressing sepsis comprehensively, we can help to improve individual lives with positive outcomes for patients and further reducing the burden of this devastating condition on our healthcare systems.

In conclusion, the early identification, detection and timely treatment of sepsis are crucial due to the high mortality rate and significant degree of morbidity associated with the condition. Sepsis management is a complex and challenging area of medicine that requires the expertise of highly trained professionals. Despite advances in medical technology and research, sepsis remains a leading cause of death worldwide. Therefore, it is essential that healthcare providers continue to prioritize sepsis detection and management to improve patient outcomes. By implementing evidence-based sepsis protocols and utilizing multidisciplinary teams, healthcare providers can improve early recognition, identification and overall treatment of sepsis, which will improve patient’s outcomes and reduce the burden of this devastating condition.

Despite the already done research for more than a quarter century, there is still no proven and reliable diagnostic procedure or treatment for this condition. One of the core reasons for this deficiency is that sepsis is still diagnosed clinically and physiologically, meaning that it represents many different molecularly distinct pathological trajectories.

The challenge of diagnosing and treating sepsis lies in its complexity. Sepsis can result from a wide range of infections, and each patient's response to the infection is unique. While there are some very common symptoms of sepsis, such as fever and increased heart rate, these symptoms are not specific to the condition and can be caused by other factors as well. As a result, a reliable diagnostic test for sepsis has yet to be developed.

Similarly, there is no direct treatment for sepsis. Instead, treatment focuses on managing the symptoms and addressing the underlying infection. Antibiotics are often used to treat the infection, while supportive care, such as IV fluids and oxygen therapy, is used to manage symptoms like low blood pressure and respiratory distress.

The application of AI in the clinical field is becoming increasingly prevalent and has the potential to significantly improve patient's health outcomes. As AI technology continues to advance, it is likely that machines will be given more responsibility in making medical decisions. This shift has the potential to widely improve clinical practice and patient's prognosis.

One specific area where AI could have a dramatically impact is in the overall management of sepsis. Sepsis is a potentially life-threatening complication that can arise from an infection. Currently, clinicians rely on a combination of clinical judgment and diagnostic tests to diagnose and treat sepsis. However in the future, a lot of the duties related to sepsis management could be carried out independently by AI or improved by specialised algorithms.

For example, it could be used for analyzing the patient's data, such as vital features and laboratory findings, to identify early signs of sepsis and alert clinicians to the need for intervention. AI could also be used to personalize treatment plans for patients based on their individual risk factors and response to treatment.

While there are certainly challenges to implementing AI in the medical field, the potential benefits are significant. By leveraging the power of AI, clinicians may be able to improve patient outcomes and deliver more efficient and effective care.

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