



INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X

Impact Factor: 6.078

(Volume 10, Issue 4 - V10I4-1184)

Available online at: <https://www.ijariit.com>

Preventive Healthcare Diagnostics Leveraging Machine Learning

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ABSTRACT

The healthcare system in India is facing unprecedented challenges due to rising population, inadequate healthcare infrastructure, higher doctor-to-patient ratio and lack of healthcare awareness in our society. Technology is the only saviour to bring in the much-needed transformation required in the healthcare space. One such idea is Predictive Healthcare Analytics which has the potential to revolutionize healthcare industry by providing insights that improve patient outcomes, optimize usage of existing resources, and enhance overall efficiency. It leverages data, analysis algorithms, and machine learning techniques to forecast future health outcomes and trends. This approach enables doctors to anticipate potential issues and proactively address them, rather than responding reactively.

Keywords: - Digital Healthcare, Predictive Healthcare, Data Analytics, Artificial Intelligence, Machine Learning

1. Introduction

The healthcare system in India is facing unprecedented challenges. Around 69% of Indian population live in rural areas who don't have access to standard healthcare system. People don't even have access to basic healthcare services like regular health checkups, periodic medical tests, and more importantly access to doctors. Even if they have, they don't understand what the doctors ask or explain and how to respond either proactively or reactively to health related issues. Furthermore, doctors don't have enough time to explain the details and even if they explain, patients struggle with understanding the basic medical terms.

India has approximately 1 doctor for every 11,082 people. According to World Health Organization (WHO), the ratio ideally should be 1 doctor per 1,000 people. Hence, India needs 10 times than the current healthcare infrastructure - doctors, medical colleges, diagnostic centres, medical programmes, etc.

Beyond geographical disparities and inadequate healthcare infrastructure, several other factors are also posing significant challenges for the healthcare system in India. The Indian government and its various organizations are working to address these issues through initiatives like increasing seats in medical colleges, promoting telemedicine, and improving healthcare infrastructure. However, these are not adequate steps to address the growing demand in the healthcare space.

Overall, health awareness is extremely low in India. People don't have the basic healthcare awareness about how to deal with normal or critical health related issues. If awareness is increased, around 70-80% of the diseases such as flu, fever, infections due to weather change, diabetes, cholesterols, etc. can be self-cured or can be cured at early stages.

Most importantly, due to inadequate doctor-patient ratio, doctors' time is very crucial and with the limited resources in hand, we need to devise a new strategy either to increase the availability time of doctors or reduce the dependency on the doctors we have. While many may not prefer to have a self-diagnosis or self-treatment plan, it's important to empower doctors with adequate information in hand so that they can attend to more patients in less time. This is possible only through the use of technology.

1.1 Technology as an Enabler

According to a United Nations Population Fund report, the number of people aged 60+ in India will increase from 100M in 2011 to 300M by 2050. And of these 300M, 200 M+ will suffer from chronic ailments such as cancer, cardiovascular diseases, diabetes and more. In addition to it, every year around 600M-800M suffer very minor health issues such as cold, fever, infection due to weather change, stomach infection, etc. which need very standard medical attention. The incidence of diabetes is calculated to be 8.4%, while hypertension is 10% and common cancers (oral, breast and cervix) is 0.1% of total incidents or visits to doctors reported. The average medical expenditure of Indians in a private hospital comes to around INR 34,000. Moreover, for life-threatening diseases such as cancer, the spend in a home increases 36-45% more than the standard cost of living.

A rising middle-class, state-of-the-art healthcare facilities, expert physicians, and increased dependency on technologies to facilitate healthcare at the prevention stage are driving the demand for using technology driven diagnostics system to detect, prevent and cure diseases at an early stage.

The much needed transformation in the healthcare space can be adopted by leveraging technology. Technology is the only saviour to predict or prevent future health issues for rising chronic or other common diseases and Predictive Healthcare Analytics is a step towards that. It has the potential to revolutionize healthcare industry by providing insights that improve patient outcomes, optimize resource use, and enhance overall efficiency. It leverages data, analysis algorithms, and machine learning techniques to forecast future health outcomes and trends. This approach enables doctors to anticipate potential issues and address them proactively rather than responding reactively.

The solution is about developing and offering a Preventive Healthcare Diagnostics Platform to the doctors that has the ability to source data about the patient from multiple sources – patient's health data, personal illness history, current symptoms, similar conditions in his/her region, family tree, family health history, lab records, demographics data – correlate and analyze all these information, predict the probable disease and feeding the outcomes with evidences to doctors before the patients visit them. As per a Deloitte report, Indian healthcare market which is worth \$100B, is likely to grow at 23% CAGR to reach \$280 B by 2027. So, commercially such kind of platforms or solution will bring in a huge commercial success for the aspiring entrepreneurs as well.

In this research report, we are going to explain how a sophisticated diagnostics platform can be built using technology to diagnose diseases or predict pandemic outbreak well in advance.

2. Preventive Healthcare Analytics Platform

The solution aims at providing an accessible, simple to use, fast and cost-effective healthcare diagnostic service at fingertips leveraging the power of technology to help doctors, healthcare professionals and patients in the following ways -

- Simplify the meaning of "healthcare" in an affordable way
- Predict diseases well in advance and recommend ways of treatment
- Act as a virtual assistant and guide doctors or patients at each step
- Increase healthcare awareness and prevent chronic diseases or healthcare emergencies
- Improve the overall lifespan of people and help them to live a healthy life

What it needs from patients

1. Current symptoms
2. Illness history
3. Family Tree (automatically builds the tree by connecting patients data with his/her family members)
4. Family history
5. Lab test results
6. Treatment history
7. Personal wearables data to understand the current state or any critical alerts

What else it uses

1. Historical as well as current state of healthcare emergencies in the same region.
2. Demographics data with similar current or historical symptoms/medical history.
3. Geographical data
4. Healthcare emergency alerts from government and non-government organizations like WHO

What it generates

1. Predicts the possible diseases or health state of patients
2. Recommends care plan for patients
3. Possible pandemic outbreak like COVID-19
4. Generates alerts for emergency services in case of critical situations

How it benefits different users

1. Doctors
 - Acts as a medical assistant to diagnose diseases by analyzing all information available in shortest possible time
 - Recommends treatment plan based on the predicted health state
 - Automatic follow-up with patients to check and monitor the progress during the treatment
2. Patients
 - Acts as a personal healthcare assistant to guide in any medical situation
 - Increases healthcare awareness by guiding them with dos and don'ts
 - Periodic follow-ups about the progress and recommends any change to the treatment plan
 - Collects data automatically than asking them to provide the same information to different doctors
3. Healthcare Professionals or Emergency Services
 - Quick insights into health state of any individuals in similar demographics
 - Alerts in case of any medical emergencies in the vicinity
 - Notifications about recommended medical tests required for individuals
4. Government or Non-Government Organizations
 - Alerts about possible pandemic outbreak well in advance
 - Action plans and other information about how to react in emergencies
 - Spread healthcare awareness among people by sharing tips, suggestions and action plans

Integrated Healthcare Ecosystem

Such technology systems will help to build a wider ecosystem faster by bringing in all stakeholders to a single ecosystem. It will solve problems that humans have tried over the years. It will help to -

1. Promote and build a larger well connected healthcare ecosystem
2. Bring in new players such as healthcare professionals, healthcare infra, diagnostic labs, emergency services, healthcare organizations, etc. to the ecosystem faster
3. Prevent chronic diseases for a wider population
4. Build a healthy and wealthy society

3. Opportunities

The platform is envisioned considering the following SWOT analysis in mind and every user of the platform should use it judiciously for an effective outcome.

Strengths

- Healthcare is the need of everyone but it is the most ignored space
- Only technology can bring in the much required transformation

Weaknesses

- Healthcare is complex and driven mainly by well trained professionals
- Dominated by big players

Opportunities

- Ignored and non-transformed space, hence wider opportunities
- Disruption will come only through technology
- Broader buying centres or users - Healthcare Providers, Patients, Government/Non-government organizations etc.

Threats

- Big Players exist
- Penetration in existing ecosystem is difficult
- Huge investment required

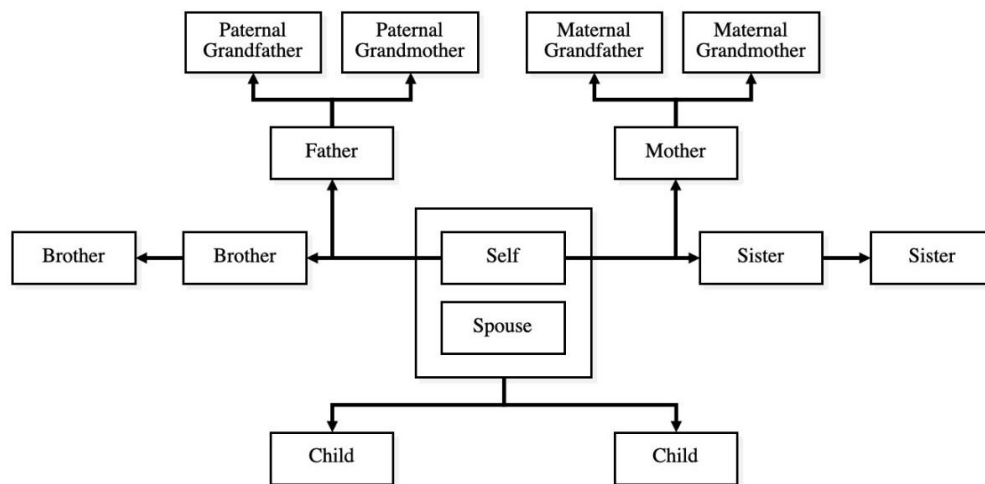
4. Methodology and Solution

The following section explains how the solution works by integrating with various systems and users in the overall healthcare ecosystem.

Sources of data

1. Patient data
 - Current symptoms or problems
 - Patient's historical health records (illness, treatment, etc.)
 - Doctor's medical notes
 - Continuous health data from personal wearables
 - Medical/Clinical test results
 - Family history
 - Food habits
 - Lifestyles
2. Geographical data
 - Similar symptoms in the same city/region
 - Recent outbreak like COVID, Swine Flu, etc. in the same region
3. Global Health System data
 - Data from WHO for similar outbreak or symptoms
 - Any recent advisories from WHO or IMA (Indian Medical Association)

The system automatically links patients with other members in the family by analyzing their relationship and build the family tree. As most of the diseases are believed to be genetically transferred, an accurate family tree with medical history is important in the diagnosis process followed by doctors. However, it's not possible for doctors to analyze massive amount of data quickly without spending enough time on each and every aspect of symptoms and history.



Family Tree with historical illness history

Machine learning (ML) can transform preventive healthcare by enabling more personalized, proactive, and data-driven approaches to maintaining health and preventing diseases. It has the potential to significantly enhance preventive healthcare by providing more accurate, personalized, and timely interventions.

ML algorithms can analyze vast amounts of health data to predict the likelihood of developing certain medical conditions. ML models can evaluate patient data to predict risks. Algorithms can identify patterns that signal early stages of diseases, potentially before symptoms appear.

In this solution, I am proposing Machine Learning models to be adopted for data analysis as the core of the solution. In the entire data engineering and processing pipeline, the Intelligence box is about adopting ML models to correlate, analyze and predict health risks.

Using Predictive Analytics Platform

1. Platform gathers continuous information from various sources as mentioned above

2. The Data Processing Platform

- Segregates the data and correlates all data points specific to the patient
- Correlates the patient data with
 - Family tree and their historical illness
 - Geographical data with similar symptoms or conditions
 - Global health system data with similar symptoms or conditions

3. The Predictive Analytics Platform provides the following outcomes

- Applies Machine Learning algorithms to analyze all information available
- Provides insights into historical, current and future state
- Diagnoses and predicts the most likely state of patients and remedies to address the same
- Identifies the undergoing treatment plan and provides recommendations
- Patients get to know their current medical conditions and probable future health state

4. Doctors get to know

- more about the patient - current medical state, medical history, current medication, treatment, medicines, dosages, etc.
- A possible health state – help them to know more about the patients in seconds before suggesting any treatment.
- The system helps the patients and doctors with the recommendations

5. Connects and orchestrates the actions in the larger healthcare ecosystem

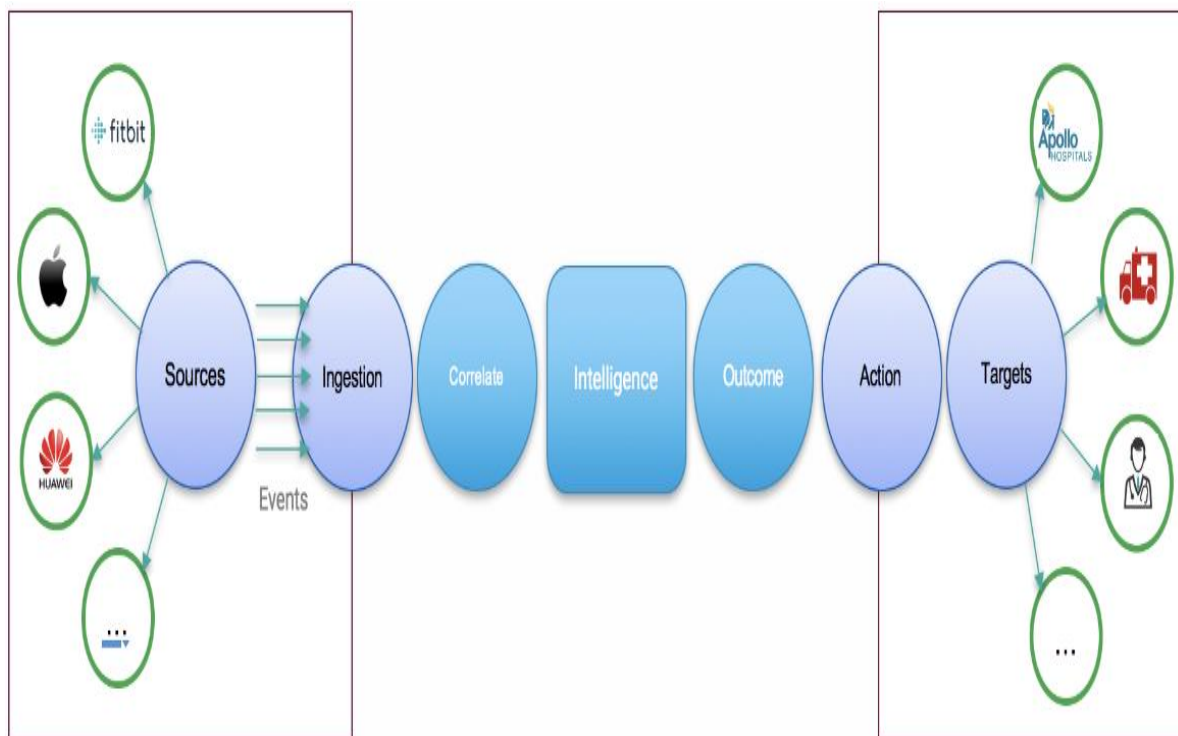


Fig 3: Data Processing Pipeline

The above diagram explains how the predictive analytics system is connected with various sources on the left and healthcare ecosystem on the right. Based on the predictions on the current state and possible treatment plan, the system can connect the patient or sends alerts to various healthcare targets like

1. Doctors
2. Hospitals
3. Ambulance
4. Emergency Services
5. Diagnostic Labs
6. Healthcare professionals
7. Family or Relatives

The Health Dashboard presents a view about the patient which can be used by the Doctors for a quick preview into the current state and possible state. The system collects the data and presents a near real-time view of the patient – ranging from RBC values to Platelet count.

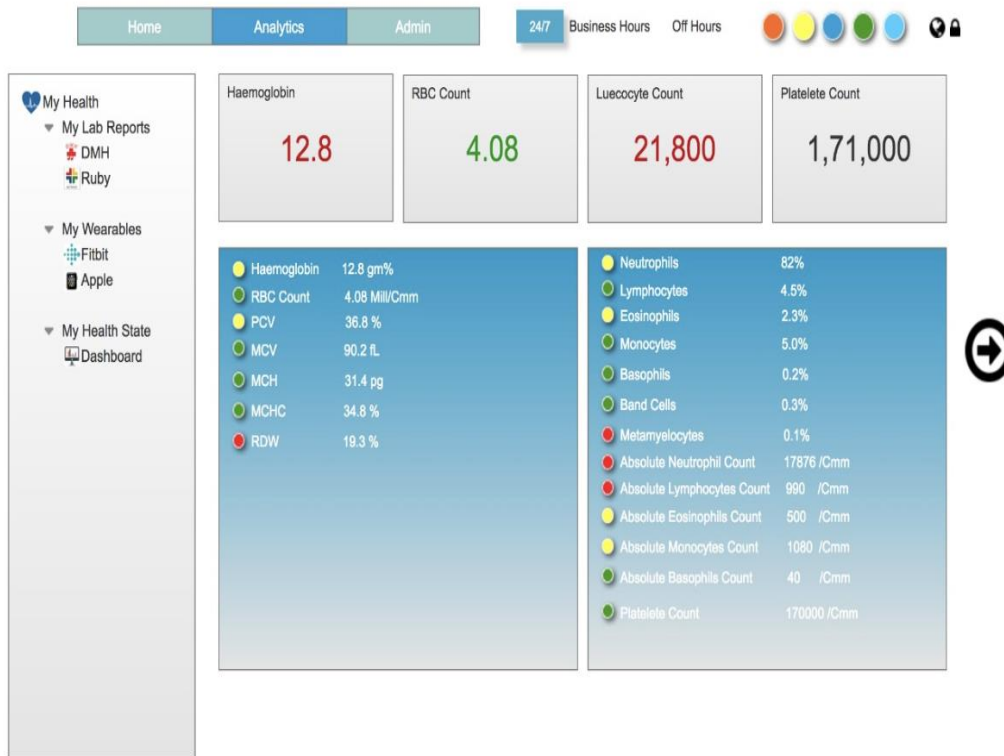


Fig 4: Patient Dashboard

The view below presents how a correlated state of various medical parameters of the patient looks like. In this view, the Liver Function Test results are linked with Leucocyte and RBC results. It immensely helps the doctors as they don't have time to look at all the reports and analyze each and every parameter reported from the test results. If the system can do all these complex jobs automatically, doctors won't have to spend a lot of time to analyze it manually. This will significantly accelerate the efficiency of the doctors to diagnose diseases accurately.

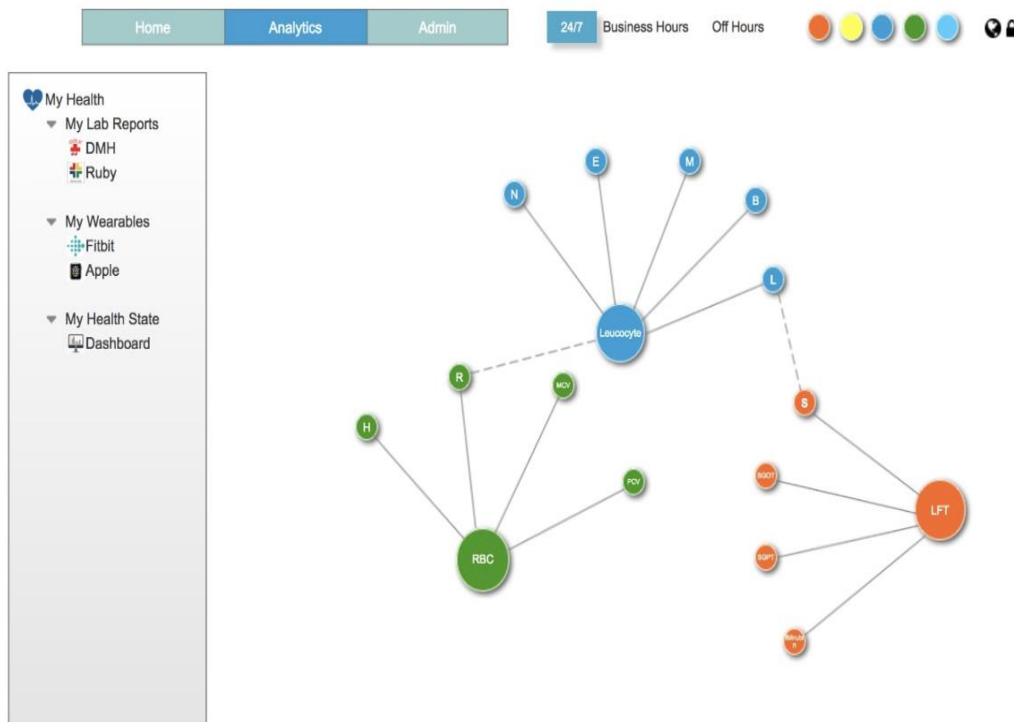
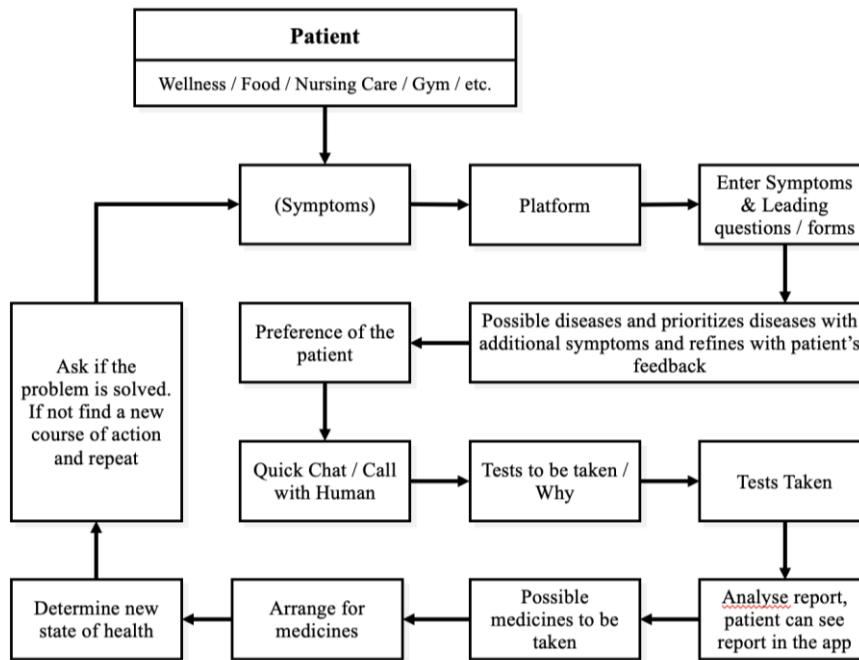


Fig 5 : Correlated View of Health Parameters

In addition to predicting diseases and recommending treatment plan, additional steps can also be introduced for a patient-system interaction for continuous follow-ups and closure of the cases as shown in the diagram below.



5. Conclusion

Predictive Healthcare Analytics involves using data and advanced analytics techniques to anticipate future health outcomes and trends. Here's a summary of the key conclusions about its impact and potential:

5.1 Improved Patient Outcomes

It helps individuals at risk of developing certain conditions before they manifest. Early intervention can improve patient outcomes, reduce the severity of diseases, and in many cases, prevent conditions from developing.

5.2 Reduced Pressure on Doctors

By leveraging a Preventive Healthcare Analytics platform, the time required for doctors to analyze the patient's data will be significantly reduced. With the same number of doctors, more patients can be attended to. This will also reduce pressure on the existing healthcare infrastructure as not every small symptom needs a visit to the doctor. Secondly, the healthcare system can be alerted to attend critical cases before even the patients reach out to them.

5.3 Global Pandemic Outbreak

It will help to analyze geographical data with most prevailing symptoms and can predict a possible pandemic outbreak. Imagine if we had such a predictive platform like this before COVID-19, it could have easily predicted the state well in advance by analyzing symptoms like fever, cold, lungs infection, etc and alerted global organizations or local authorities.

5.4 Effective Treatment Plan

By analyzing patterns and predicting disease progression, healthcare providers can tailor treatment plans to individual needs. This personalized approach can lead to more effective management of chronic diseases and better overall health outcomes.

5.5 Cost Efficiency

Predictive analytics can lead to cost savings by optimizing resource allocation, reducing hospital admissions, and minimizing unnecessary tests and procedures. By predicting high-risk patients, healthcare systems can focus resources on those who need it most, potentially reducing overall healthcare costs.

5.6 Public Health Management

Predictive analytics can help identify health trends and emerging public health issues within specific populations. This information allows for targeted interventions and preventive measures, improving public health and managing outbreaks more effectively.

5.7 Integration with Healthcare Ecosystem

For predictive analytics to be truly effective, it must be integrated into clinical workflows and decision-making processes. Healthcare professionals need to interpret and act on predictive insights in conjunction with clinical judgment and patient preferences.

In conclusion, predictive healthcare analytics holds significant promise for transforming healthcare delivery by enhancing patient care, improving efficiency, and managing costs. However, its success depends on addressing challenges related to data integration,

privacy, and ethical considerations, and ensuring that predictive insights are used to complement, rather than replace, clinical expertise.

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