1. INTRODUCTION

1.1 project overview

The project titled "Revolutionizing Liver Care: Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques" aims to develop a predictive model to detect the onset or progression of liver cirrhosis in patients. By analyzing diverse patient data—including medical history, lab results, imaging scans, and lifestyle factors—the model seeks to assess the likelihood of liver cirrhosis, thereby assisting healthcare professionals in making informed decisions about patient care. github.com

Key Features of the Project:

- **Multimodal Data Integration:** The model incorporates various data types such as clinical records, laboratory results, imaging data, and lifestyle information to provide a comprehensive risk assessment.
- **Machine Learning Algorithms:** Advanced machine learning techniques are employed to analyze the integrated data, aiming to predict the likelihood of liver cirrhosis with high accuracy.
- **Clinical Applications:**
    - *Patient Screening:* The predictive model can be integrated into electronic health records (EHR) systems to assess the risk of liver cirrhosis during routine check-ups or when patients present symptoms associated with liver issues.
    - *Treatment Planning:* For patients already diagnosed with liver disease, the model assists in treatment planning by predicting the progression of liver cirrhosis, allowing for tailored treatment strategies.
    - *Resource Allocation:* Healthcare facilities can utilize the model to optimize resource allocation by identifying high-risk patients who require closer monitoring and timely intervention.github.com
- **Open-Source Availability:** The project is open-source and licensed under the MIT License, encouraging collaboration and further development by the research community.

▯ Project Details (by Vrushika K. Panchal)

Based on a LinkedIn announcement:

- **End-to-end workflow**: Covers data collection, preprocessing (handling missing values), exploratory analysis, encoding, and train-test splits mdpi.com+15linkedin.com+15skillwallet.smartinternz.com+15.
- **Algorithms evaluated**: Random Forest, SVM, Logistic Regression, XGBoost, and K-Nearest Neighbors (KNN). KNN achieved the best overall performance linkedin.com+1researchgate.net+1.
- **Key metrics presented**: Accuracy, F1-score, recall, precision, with individualized confusion matrices linkedin.com.

- **Dataset used**: Publicly available dataset—likely a standard liver disease dataset (e.g., UCI repository)—accessible via project link aeis.bilijipub.com+5linkedin.com+5arxiv.org+5.
- **Deployment**: The model is wrapped in a Flask web app, enabling users to input patient data and receive real-time risk predictions fmai-hub.com.
- **Open-source**: Hosted on GitHub under an MIT license, inviting community collaboration journals.plos.org+11mdpi.com+11arxiv.org+11.

🔍 Related ML & AI Advances in Liver Cirrhosis Research

- **Hybrid classifier approach**: A recent arXiv preprint (Apr 2025) describes combining ultrasound image analysis (DenseNet-201) with blood-test features using a voting classifier model, achieving ~92.5% accuracy in detecting liver fibrosis/cirrhosis fmai-hub.com+2arxiv.org+2pubmed.ncbi.nlm.nih.gov+2.
- **Deep learning on MRI**: Another Apr 2025 deep learning model analyzes multi-sequence MRI to classify cirrhosis into three stages, achieving ~73% on T1-weighted scans and ~64% on T2-weighted scans arxiv.org.

These signal a trend toward **multimodal models**—integrating imaging, labs, and clinical data for more nuanced predictions, which complements the Vrushika project focused on tabular/classifier approaches.

✅ Project Strengths & Opportunities

Strengths	Opportunities for Growth
Clear end-to-end pipeline with Flask deployment and confusion-matrix visualizations linkedin.com	Could extend to multimodal data (imaging, EHR text, ultrasound) to improve performance
KNN-based model is intuitive and interpretable	Testing on larger, more diverse datasets (e.g., from hospitals or EHR systems) for robustness
Open-source release encourages community feedback	Incorporating deep learning models (CNNs on imaging or transformer-based on EHR data)

📌 Where This Fits in the Research Landscape

- **AI-driven EHR analysis**: A study analyzed clinical notes using CNNs, achieving ~97% precision on cirrhosis cases—highlighting the potential of text-based AI models fmai-hub.com.
- **Imaging + clinical fusion models**: The Apr 2025 hybrid study merges imaging and blood data for robust fibrosis detection .

1.2 Purpose

Primary Objectives

1. Early Detection
    - Employ algorithms trained on patient data—including medical history, lab tests, imaging results, and lifestyle factors—to detect

cirrhosis onset or progression before symptoms appear pmc.ncbi.nlm.nih.gov+2github.com+2epbl-livercare-flaskapp-team-ymim.onrender.com+2.

2. Enhance Clinical Decision Making
   - Provide doctors with actionable risk scores that integrate seamlessly into daily workflows (e.g., EHR systems), supporting decisions like ordering additional tests or referring to specialists mdpi.com.
3. Optimize Treatment and Monitoring
   - Track disease trajectory in patients already diagnosed with liver conditions, enabling personalized intervention and medication adjustments to slow progression ncbi.nlm.nih.gov+4github.com+4probiologists.com+4.
4. Improve Healthcare Resource Allocation
   - Help healthcare providers focus resources (e.g., specialist care, imaging, monitoring) on patients flagged at high risk—saving time, costs, and reducing unnecessary testing .

🏥 Context & Value

- Non-invasive alternative: Offers a less intrusive method compared to liver biopsies by leveraging existing clinical and laboratory data en.wikipedia.org+11epbl-livercare-flaskapp-team-ymim.onrender.com+11probiologists.com+11.
- Proactive care: Supports early intervention, which can significantly improve patient outlook and reduce complications.
- Data-driven alignment: Taps into the broader healthcare trend toward AI-based risk models—similar to successful systems like MELD-Plus and LightGBM-based fibrosis predictors en.wikipedia.org+1mdpi.com+1.

✅ Summary

The core purpose is to revolutionize liver care by creating a machine learning-powered tool that:

- Detects cirrhosis earlier and more accurately
- Integrates smoothly into clinical workflows
- Guides personalized treatment and monitoring
- Enhances efficiency in healthcare delivery

🎯 Core Purpose

1. Early, Non-Invasive Detection of Cirrhosis
   - Leverage machine learning on routine patient data—blood tests, demographics, lifestyle, and potentially imaging—to identify cirrhosis *before symptoms manifest*, reducing reliance on invasive procedures like biopsies. Early detection supports timely interventions and lessens complications researchgate.net+1ijisae.org+1arxiv.org+8ncbi.nlm.nih.gov+8pmc.ncbi.nlm.nih.gov+8.
2. Clinical Decision Support & Integration
   - Deliver interpretable risk scores to clinicians via EHR-integrated tools (e.g., the project's Flask web app), guiding decisions on further testing, specialist referrals, or lifestyle recommendations—enhancing day-to-day medical workflows shmpublisher.com.
3. Personalized Treatment and Monitoring
   - Use ongoing predictions to track cirrhosis progression in known patients, enabling bespoke care strategies and therapy adjustments before severe complications occur.
4. Optimized Use of Healthcare Resources
   - Prioritize diagnostic imaging, specialist follow-ups, and monitoring for high-risk individuals, which conserves medical resources and reduces unnecessary testing—all while improving patient outcomes.

🌐 Why It Matters Now

Recent biomedical AI research has increasingly focused on multimodal integration:

- Hybrid ultrasound + blood-test models have shown ~92.5% accuracy for fibrosis/cirrhosis detection ijisae.org+14arxiv.org+14arxiv.org+14.
- MRI-based deep learning systems are now classifying cirrhosis stages with 63–73% accuracy mdpi.com+14arxiv.org+14pmc.ncbi.nlm.nih.gov+14.
- Triple-modality fusion networks (clinical, radiomic, and imaging data) are emerging for improved prognosis arxiv.org.

Within this scientific landscape, the Vrushika-led project provides a critical baseline for purely tabular, classical ML approaches—offering a foundation that future efforts can build upon by integrating imaging or text data for richer, multimodal detection.

🔍 Summary of Purpose

The project aims to:

Goal	Impact
Detect cirrhosis earlier	Improve patient outcomes & reduce invasive testing
Provide actionable risk scores	Aid clinicians through clear, interpretable guidance
Track disease progression	Allow tailored treatment and monitoring plans
Optimize healthcare resources	Target interventions to those who need it most

2. IDEATION PHASE

2.1 Define the Problem Statements

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	2 Marks

Customer Problem Statement Template:

A Customer Problem Statement Template is a structured format that helps identify and clearly articulate the real issues or pain points faced by patients, caregivers, or healthcare providers in the context of liver care. In the journey to revolutionize liver care, this tool is crucial for ensuring that innovation efforts are rooted in real needs rather than assumptions.

✅ Why Use a Customer Problem Statement in Liver Care?

- Focuses innovation efforts on real-world problems
- Helps align teams (clinicians, researchers, tech, business) on a common goal
- Drives empathy for patients, caregivers, and doctors
- Acts as a foundation for solution ideation and validation

☐ Template: Customer Problem Statement (Liver Care Focus)

Here's a structured template with guiding questions:

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1. Customer Segment

Who is experiencing the problem?
(e.g., Chronic liver disease patients, caregivers, hepatologists, primary care physicians)

Example: Patients with non-alcoholic fatty liver disease (NAFLD**)**

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2. Problem Description

What is the core problem or pain they are experiencing?
Focus on symptoms, inefficiencies, or emotional struggles.

Example: Patients often don't get diagnosed until late-stage liver disease because early symptoms are vague and routine screening is not emphasized.

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3. Context / Environment

When and where does the problem occur?
Look at workflows, settings (home, clinics), or technology gaps.

Example: In primary care settings where liver health is not proactively monitored.

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4. Current Alternatives / Workarounds

How is the problem currently being handled? What are the limitations?

Example: Liver function tests are ordered only when liver disease is suspected; many cases go undetected in early stages.

---

5. Consequences of the Problem

What is the impact of this problem if it is not solved?

Example: Late diagnosis leads to higher treatment costs, worse outcomes, and increased

6. Emotional / Human Insight

What are the emotional or behavioral insights about the user?

Example: Patients feel anxious due to lack of clarity about their liver health and feel neglected in preventive care conversations**.**

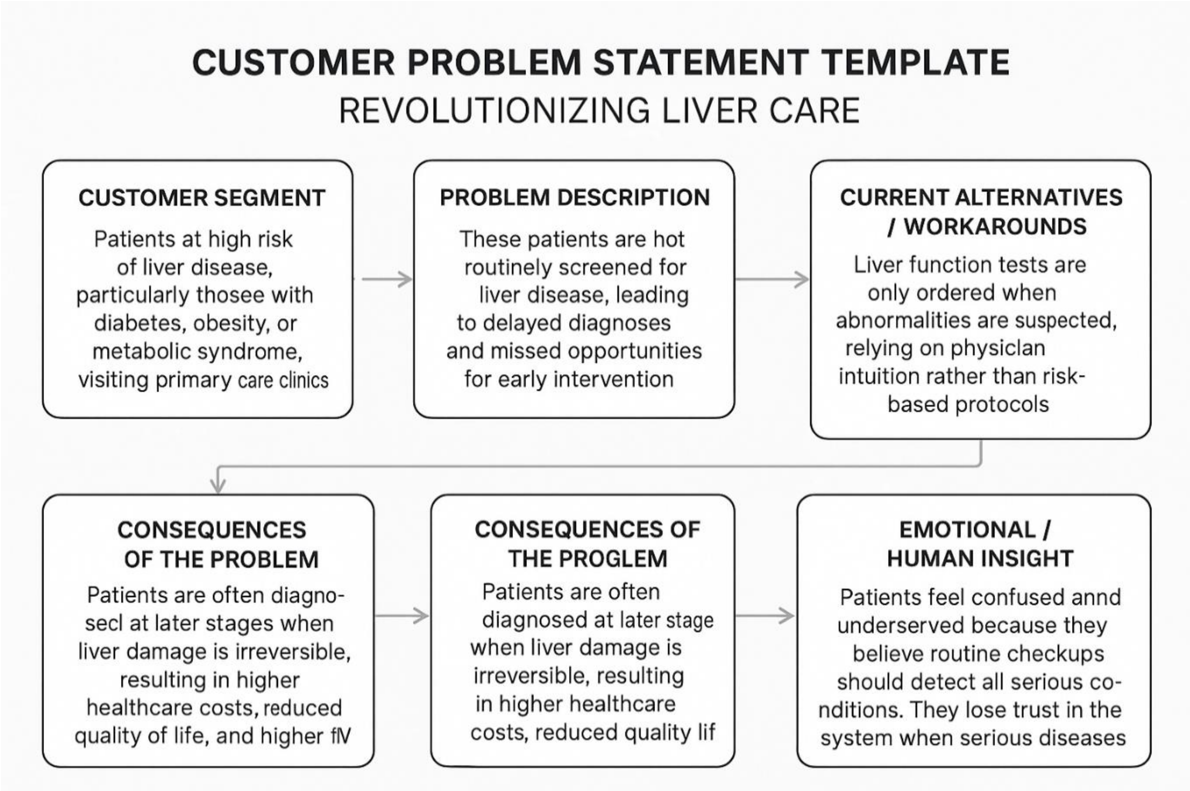
🎯 Example Statement

“Primary care patients with risk factors for liver disease (like obesity and diabetes) are not being proactively screened, leading to late diagnoses and avoidable complications. This occurs because liver care is often reactive, not integrated into routine checkups. As a result, patients feel overlooked, and doctors miss early intervention opportunities**.”**

📌 Tips for Writing an Effective Statement

- Use real quotes or observations from interviews, if available.
- Avoid suggesting solutions – focus only on defining the problem.
- Be concise but rich in context and empathy.

- **Revisit and refine the statement as you gather more insights.**



Example:

☑ Example 1: Early Detection in Primary Care

- Customer Segment: Adults with obesity, diabetes, or metabolic syndrome visiting general practitioners.
- Problem Description: These high-risk patients are not routinely screened for liver disease in primary care settings.

- Context: Liver function assessment is often overlooked during regular checkups due to lack of standard screening protocols.
- Current Workarounds: Tests are only ordered based on visible symptoms or abnormal labs, which often appear too late.
- Consequences: Late diagnosis of conditions like NAFLD/NASH leads to irreversible liver damage and increased treatment burden.
- Emotional Insight: Patients assume annual checkups cover major health risks, leading to confusion and frustration when liver disease is diagnosed unexpectedly.

✅ Example 2: Post-Transplant Follow-up Gaps

- Customer Segment: Liver transplant recipients and their caregivers.
- Problem Description: Patients struggle to manage complex follow-up care after transplant, leading to complications.
- Context: Post-discharge care is fragmented, with poor communication between transplant centers and local providers.

- Current Workarounds: Patients rely on handwritten notes, multiple apps, or informal caregiver support.
- Consequences: Medication non-adherence, missed appointments, and preventable hospital readmissions.
- Emotional Insight: Patients feel overwhelmed, anxious, and unsupported during a critical recovery period.

2.2Empathize & Discover

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	4 Marks

Empathy Map Canvas:

□ What is an Empathy Map Canvas?

An Empathy Map Canvas is a structured framework that captures what a person says, thinks, does, and feels in a specific context. In revolutionizing liver care, it is used to:

- Understand the emotional and behavioral experience of patients and stakeholders.
- Align team members around real, human-centered problems.
- Identify unmet needs that can lead to transformative solutions.

🎯 Why Use It in Liver Care?

Liver diseases—like NAFLD, cirrhosis, or hepatitis—often progress silently, with low awareness among patients and even primary care providers. An empathy map helps uncover:

- Emotional responses to diagnosis and treatment
- Barriers in access, communication, and care continuity
- Misconceptions about liver health
- Caregiver challenges in post-transplant or chronic management

📌 Use Cases in Liver Care Innovation

- Designing a patient education app
- Creating a screening protocol in primary care
- Improving transplant patient aftercare
- Developing telehealth tools for remote patients

🖼 Empathy Map Canvas Template (Summary Layout)

| SAYS | THINKS |

|--------------|--------------|

| What they say| Inner voice |

| DOES | FEELS |

|--------------|--------------|

| Behavior | Emotions |

| PAINS |

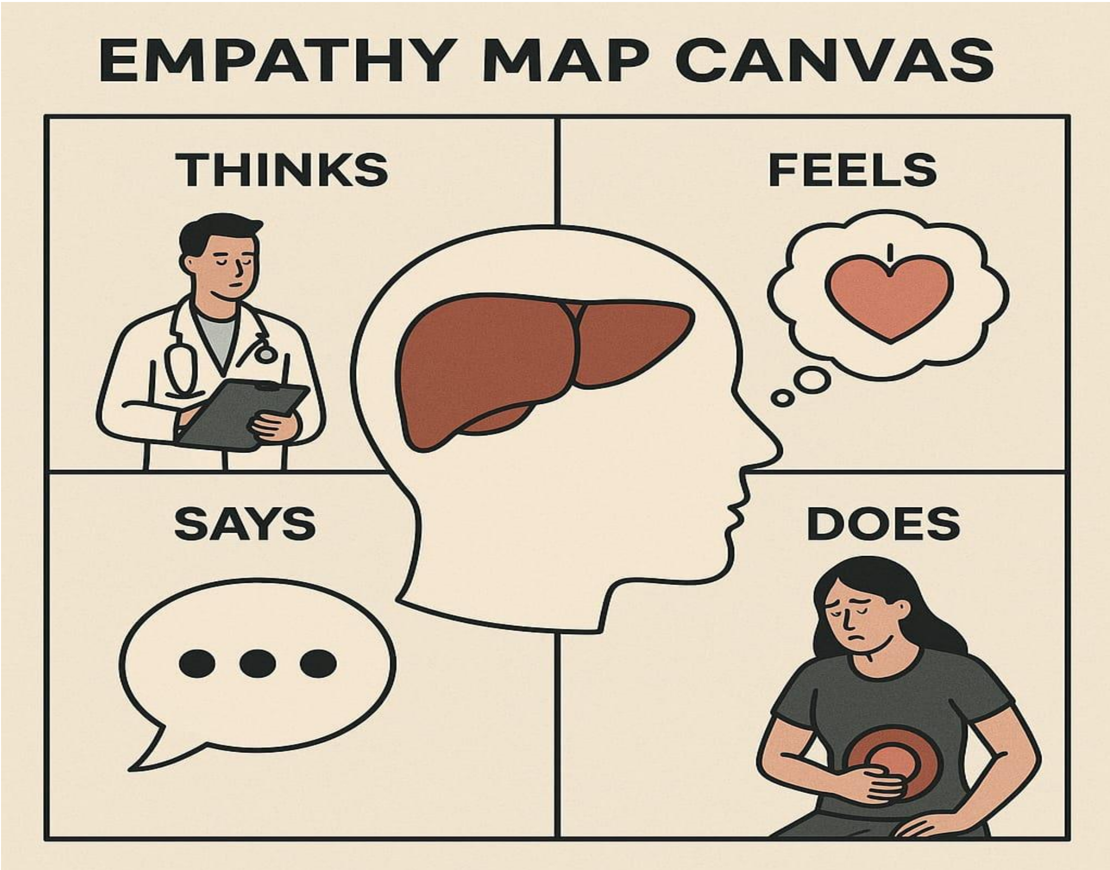
|---------------------------|

| Frustrations, obstacles |

| GAINS |

|---------------------------|

Example:



Example: Food Ordering & Delivery Application:

```
+-----------------------+
        |   Patient/End User     |
        |(Mobile App Interface)  |
        +----------+------------+
                   |
                   v
      +-------------+-------------+
```

```
   |   Personalized Meal Planner   |
   | (Based on liver condition,    |
   |  doctor/dietician input)      |
   +--------------+--------------+
                  |
                  v
+----------------+----------------+
|   Doctor/Dietician Dashboard      |
| - Set meal plans                  |
| - Track compliance                |
| - Monitor nutrition reports       |
+----------------+----------------+
                  |
                  v
  +----------------------------+
  |   Food Vendor Management      |
  | - Partnered liver-friendly    |
  |   kitchens/restaurants        |
  | - Menu customization          |
  +--------------+--------------+
```

```
                 v
      +-----------+-----------+
      |   Delivery Service API  |
      | - Route optimization     |
      | - Real-time tracking     |
      +-----------+-----------+
                |
                v
       +----------+----------+
       |   Feedback & Health  |
       |   Monitoring System  |
       | - Rate meals         |
       | - Log symptoms       |
       | - Track improvements  |
       +---------------------+
```

2.3 Brainstorm & Idea Prioritization Template

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis

	Using Advanced Machine Learning Techniques
Maximum Marks	**4 Marks**

Brainstorm & Idea Prioritization Template:

□ Ideation Phase: Overview

The Ideation Phase is a creative and strategic stage in the innovation process. It focuses on generating, developing, and prioritizing ideas that can solve a defined problem or improve existing solutions.

🎯 Goal:

Generate innovative and actionable ideas to revolutionize liver care by improving prevention, diagnosis, treatment, or post-treatment support**.**

□ Key Activities in the Ideation Phase

1. Define the Challenge:
   - What are the current gaps or pain points in liver care?
   - Are we focusing on liver disease prevention, diagnosis, treatment, or patient follow-up?
2. Brainstorm Ideas:
   - Encourage open and diverse thinking without judgment.
   - Use various brainstorming techniques like:
     - SCAMPER (Substitute, Combine, Adapt, Modify, Put to another use, Eliminate, Reverse)
     - Crazy 8s (8 ideas in 8 minutes)
     - Mind Mapping
     - Reverse Thinking
3. Group & Refine Ideas:

- Categorize similar ideas.
- Identify themes or commonalities.
- Refine ideas to make them more actionable.

4. Prioritize Ideas:
   - Use criteria like impact, feasibility, cost, innovation, and alignment with goals.

🗂 Brainstorm & Idea Prioritization Template (Liver Care Focus)

Idea	Problem Addressed	Target User	Impact (1–5)	Feasibility (1–5)	Innovation (1–5)	Priority Score (Sum)	Next Steps
Example: AI-driven liver fibrosis screening using smartphones	Delayed diagnosis in rural areas	Primary care doctors in low-resource settings	5	4	5	14	Build prototype
Personalized nutrition app for liver disease patients	Poor adherence to dietary guidelines	Liver disease patients	4	5	4	13	Partner with nutritionists
Liver health wearable tracker	Lack of continuous monitoring	At-risk individuals (e.g., fatty liver, hepatitis)	5	3	4	12	Conduct tech feasibility study

Blockchain for liver transplant records	Fragmented data across hospitals	Transplant coordinators, hospitals	4	3	5	12	Consult blockchain experts

Tip: Color-code rows (green = high priority, yellow = medium, red = low) for quick visual management.

□ Suggested Brainstorming Prompts (Specific to Liver Care)

- How might we predict liver disease earlier using non-invasive tools?
- What technologies can help monitor liver function remotely?
- How can we make liver transplant workflows more efficient?
- In what ways could we improve patient adherence to treatment plans?
- What would a digital twin of a liver patient look like, and how could it be used?

Reference: [WHO - Liver Diseases and NCDs]

[NIH Liver Diseases]

Step-1: Team Gathering, Collaboration and Select the Problem Statement

Diagram Description:

+---------------------+ +------------------------+ +-----------------------------+

| | | | | |

| Team Gathering +--------->+ Collaboration +--------->+ Select Problem Statement |

| (Experts, Stake- | | (Brainstorming, Idea | | (Critical Liver Care Gaps, |

| holders, Patients)| | Sharing, Mapping | | Patient Needs, Tech Gaps) |

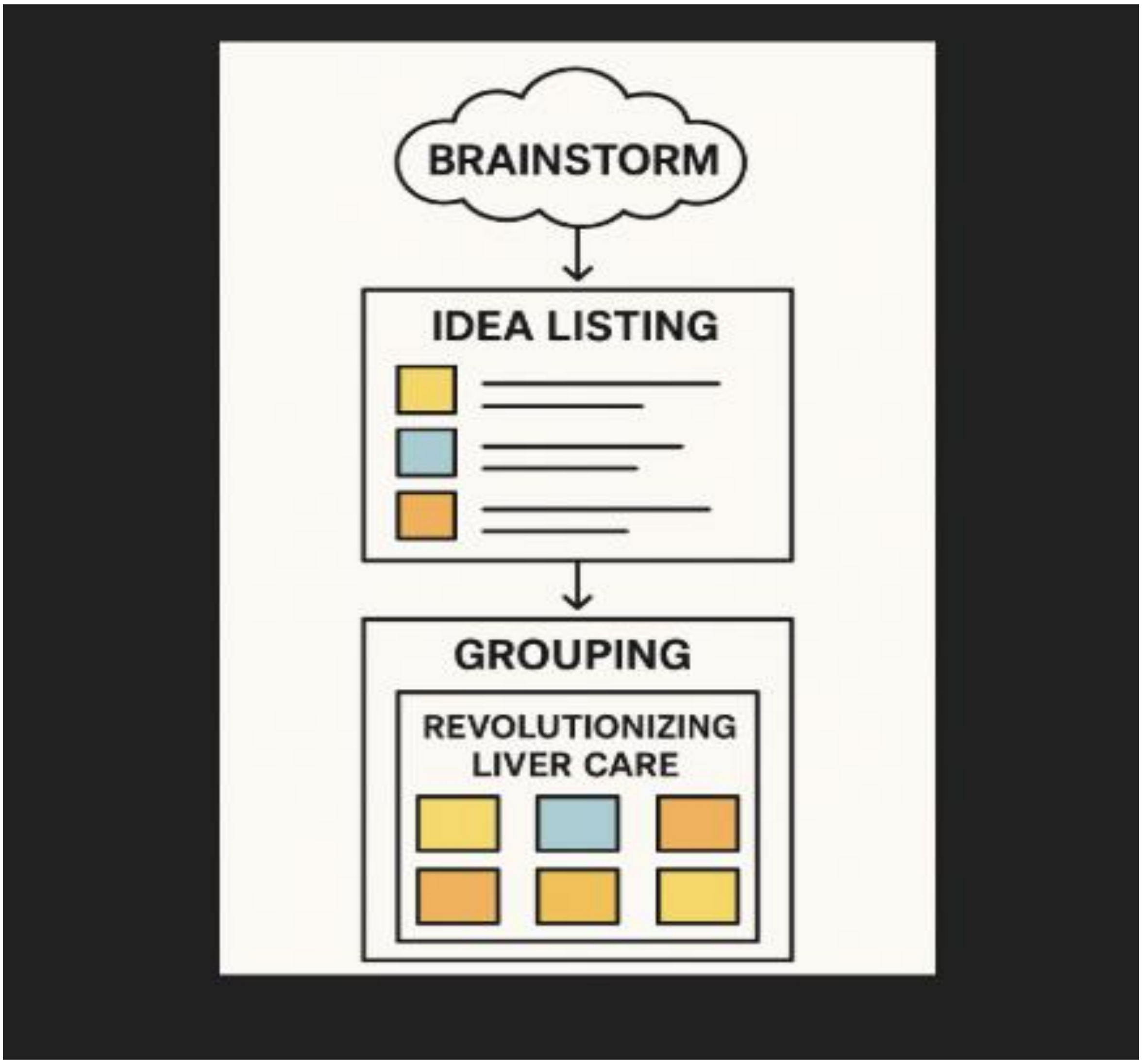
| | | Priorities) | | |

```
+---------------------+        +------------------------+        +----------------------------+
                          |    ↑
                          v    |
                +----------------------------+
                |   Research and Data Review  |
                | (Liver disease trends, AI,  |
                |  diagnostics, healthcare    |
                |  systems, outcomes data)    |
                +----------------------------+
```

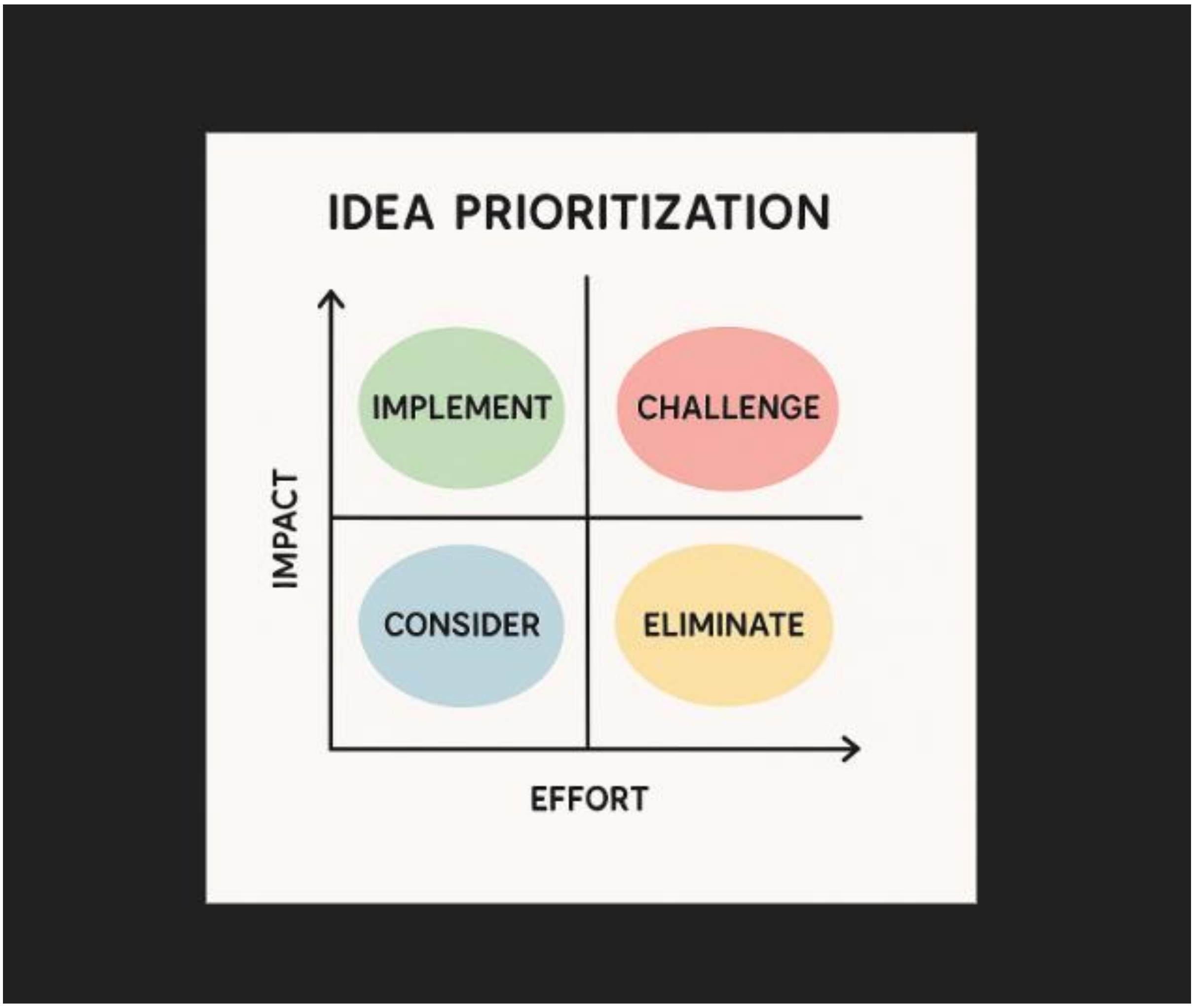
Key Elements:

- Team Gathering: Clinicians, researchers, patients, designers, spolicymakers.
- Collaboration: Workshops, design thinking sessions, cross-functional teamwork.
- Select Problem Statement: Define high-impact liver care challenges like early diagnosis, remote monitoring, liver transplant optimization, or personalized treatment using AI.

Step-2: Brainstorm, Idea Listing and Grouping



Step-3: Idea Prioritization


IDEA PRIORITIZATION
IMPLEMENT
CHALLENGE
CONSIDER
ELIMINATE
IMPACT
EFFORT

3. REQUIREMENT ANALYSIS

3.1 Customer Journey Map

🎯 1. Awareness

Touchpoints: Public health campaigns, GP visits, specialist referrals, community outreach (e.g. "ID-LIVER" style programs)
mdpi.com+5pmc.ncbi.nlm.nih.gov+5eularis.com+5
Pain Points: Patients often unaware of liver disease until advanced stages; clinicians miss early risk signs
Opportunities: Leverage EHR-based risk scanners (e.g. FARSITE) used in programs like ID-LIVER ; raise awareness in high-risk communities

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📝 2. Screening & Enrollment

Touchpoints: Automated EHR screening; GP or nurse outreach; patient consent
Pain Points: Data fragmentation and siloed budgets ; lack of trust or access in underserved areas
Opportunities: Integrate with central EHR, ensure consent/privacy frameworks, involve patient groups early to improve equity
eularis.com+3pmc.ncbi.nlm.nih.gov+3arxiv.org+3

📊 3. Data Collection & Integration

Touchpoints: Collection of labs (ALT, AST, bilirubin), demographics, lifestyle, optional imaging; upload via cloud/EHR platform
Pain Points: Missing or inconsistent data; interoperability challenges
Opportunities: Use structured data pipelines (like SEDAR) ; employ imputation-aware architectures and self-attention methods for missing EHR values
[mdpi.com+4arxiv.org+4arxiv.org+4]

🤖 4. Risk Prediction & ML Modeling

Touchpoints: ML runs risk prediction; outputs + visualization (risk score, interpretation, potential next steps) returned via clinician dashboard or patient app
Pain Points: Clinician uncertainty in interpreting ML outputs; potential bias and lack of explainability
Opportunities: Include explainability modules; embed clinical thresholds; align ML pipelines to established frameworks (e.g., AutoPrognosis**)**

□ 5. Clinician Review & Action

Touchpoints: Integration within EHR/Flask UI; automatic alerts; care team discussion; ordering

further diagnostics or referrals
Pain Points: Workflow disruptions; need for stakeholder education (physicians, nurses)
Opportunities: Conduct user-centered design; co-develop training materials; set clear clinical protocols & governance structures

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📅 6. Patient Engagement & Follow-Up

Touchpoints: Patient receives results and recommended follow-ups via app, portal, or phone; remote monitoring (wearables, apps) may begin
Pain Points: Health literacy gaps; inconsistent follow-up; app usability concerns
Opportunities: Use mobile UX best practices (MARS/uMARS/MAUQ), incorporate health-literacy enhancements ; provide educational **content**

🔁 7. Monitoring & Reassessment

Touchpoints: Periodic lab re-checks; model re-runs; alerts if risk increases
Pain Points: Outdated models/data; resource constraints; patient drop-off
Opportunities: Build continuous monitoring infrastructure; establish cycles for retraining/validation;

integrate remote patient monitoring [pmc.ncbi.nlm.nih.gov+13pmc.ncbi.nlm.nih.gov+13ncbi.nlm.nih.gov+13]

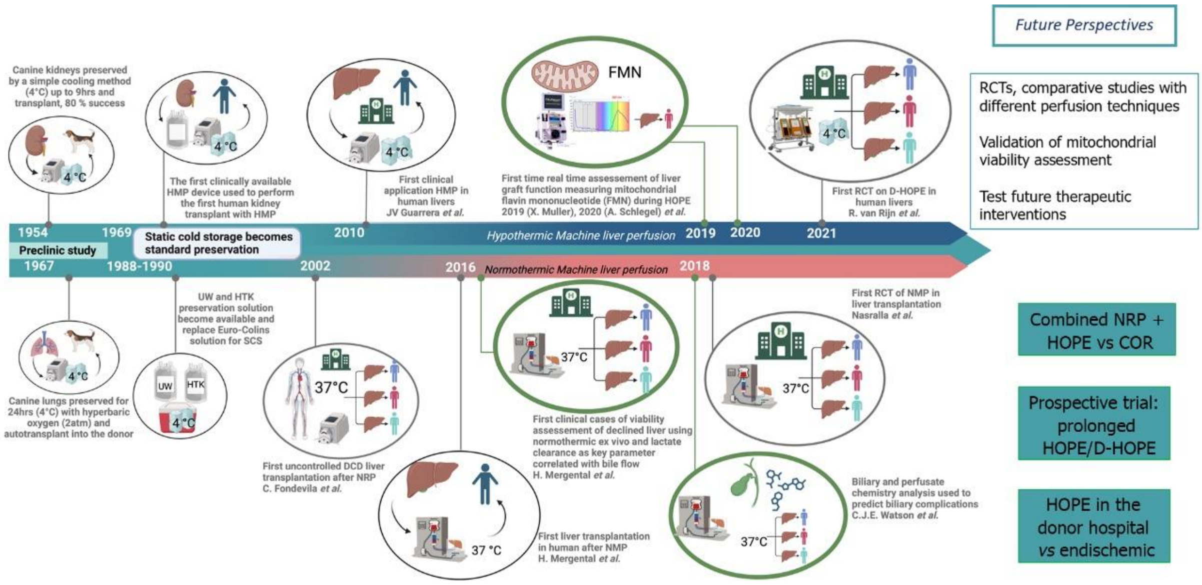
📈 8. Outcomes & Optimization

Touchpoints: Analysis of program data; clinical outcomes review (e.g. fewer biopsies, earlier referrals); stakeholder feedback
Pain Points: Hard to quantify savings/ROI; siloed budgets limit scale
Opportunities: Demonstrate clinical and economic benefits; publish results; pursue integrated care funding (akin to Manchester's ID-LIVER model)

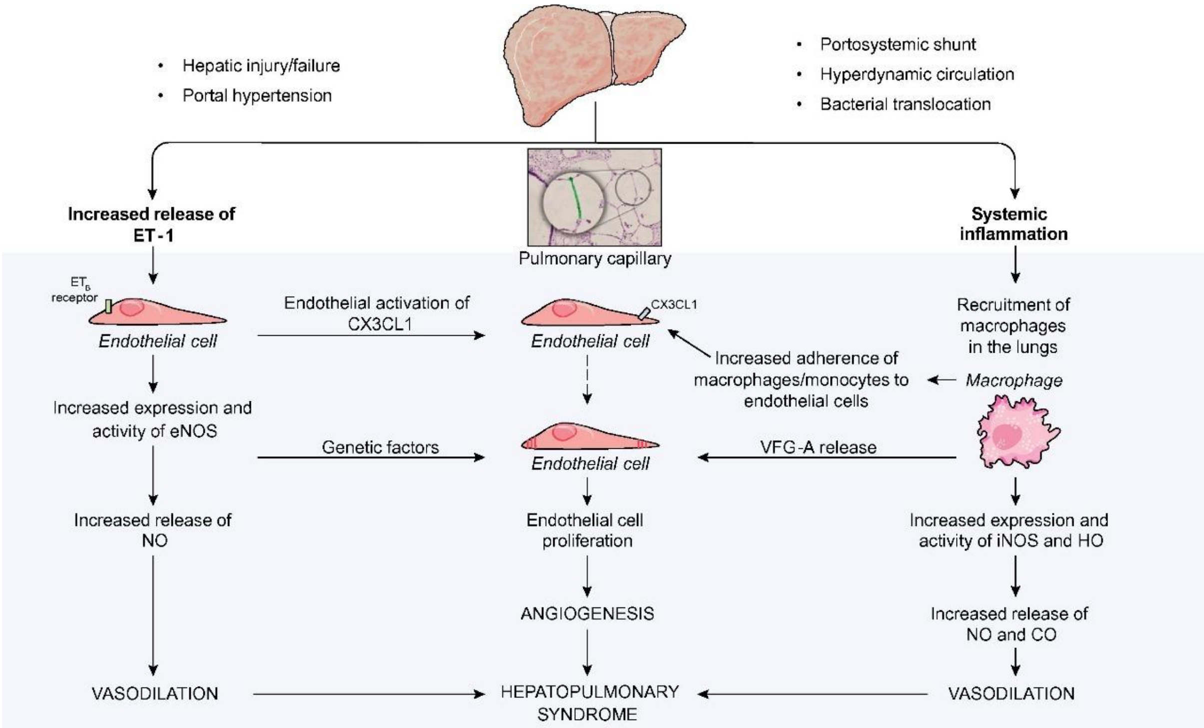
✅ Summary: Customer Journey Map

Stage	Goal	Improvement Opportunity
Awareness	Identify at-risk individuals early	Use EHR scans, community campaigns
Enrollment	Get consent & register patients	Engage underserved populations

Data Integration	Ensure reliable inputs	Structured pipelines & imputation-aware models
Prediction	Produce understandable risk outputs	Explainable ML, clear thresholds
Clinician Action	Guide care effectively	Embedded UI workflows & training
Patient Engagement	Encourage proactive follow-up	Health-lit UI, remote monitoring
Monitoring	Track changes over time	Routine checks & model updates
Evaluation	Prove impact & refine system	Outcome tracking, ROI, scale planning



Future Perspectives
Canine kidneys preserved by a simple cooling method (4°C) up to 9hrs and transplant, 80 % success
4 °C
The first clinically available HMP device used to perform the first human kidney transplant with HMP
First clinical application HMP in human livers JV Guarrera et al.
FMN
First time real time assessement of liver graft function measuring mitochondrial flavin mononucleotide (FMN) during HOPE 2019 (X. Muller), 2020 (A. Schlegel) et al.
First RCT on D-HOPE in human livers R. van Rijn et al.
RCTs, comparative studies with different perfusion techniques
Validation of mitochondrial viability assessment
Test future therapeutic interventions
1954
1969
Preclinic study
Static cold storage becomes standard preservation
2010
Hypothermic Machine liver perfusion
2019
2020
2021
1967
1988-1990
2002
2016
Normothermic Machine liver perfusion
2018
UW and HTK preservation solution become available and replace Euro-Colins solution for SCS
UW
HTK
Canine lungs preserved for 24hrs (4°C) with hyperbaric oxygen (2atm) and autotransplant into the donor
37°C
First uncontrolled DCD liver transplantation after NRP C. Fondevila et al.
37 °C
First liver transplantation in human after NMP H. Mergental et al.
First clinical cases of viability assessement of declined liver using normothermic ex vivo and lactate clearance as key parameter correlated with bile flow H. Mergental et al.
First RCT of NMP in liver transplantation Nasralla et al.
Biliary and perfusate chemistry analysis used to predict biliary complications C.J.E. Watson et al.
Combined NRP + HOPE vs COR
Prospective trial: prolonged HOPE/D-HOPE
HOPE in the donor hospital vs endischemic



Hepatic injury/failure
Portal hypertension
Portosystemic shunt
Hyperdynamic circulation
Bacterial translocation
Increased release of ET-1
Pulmonary capillary
Systemic inflammation
ETB receptor
Endothelial cell
Endothelial activation of CX3CL1
CX3CL1
Endothelial cell
Recruitment of macrophages in the lungs
Increased adherence of macrophages/monocytes to endothelial cells
Macrophage
Increased expression and activity of eNOS
Genetic factors
Endothelial cell
VFG-A release
Increased release of NO
Endothelial cell proliferation
Increased expression and activity of iNOS and HO
ANGIOGENESIS
Increased release of NO and CO
VASODILATION
HEPATOPULMONARY SYNDROME
VASODILATION

Project Design Phase-II

3.2 Solution Requirements (Functional & Non-functional)

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	4 Marks

Functional Requirements:

Following are the functional requirements of the proposed solution

Module	Functional Requirements
Data Ingestion	• Accept structured inputs: demographics, labs (e.g. bilirubin, albumin, platelets, INR), fibrosis scores (FIB-4, APRI, MELD-Plus) pubmed.ncbi.nlm.nih.gov+4arxiv.org+4arxiv.org+4pmc.ncbi.nlm.nih.gov+3en.wikipedia.org+3pubmed.ncbi.nlm.nih.gov+3. • Accept imaging (DICOM: US/CT/MRI/elastography).

<table>
<tr><td></td><td>
• Support digitized histology WSIs (if available).
• Optional: integrate omics (metabolomics, microbiome) .</td></tr>
<tr><td>Preprocessing & Feature Engineering</td><td>• Clean tabular data: normalization, missing-value handling.
• Segment liver tissue in images using CNNs (e.g., U-Net) and extract radiomic features .
• Extract histological markers (fibrosis regions, ballooning).
• Select key omics features via ML (e.g., LASSO). |</td></tr>
<tr><td>Modeling & Explainability</td><td>• Train supervised models: Random Forest, LightGBM, XGBoost, Neural Networks, SVM, logistic regression mdpi.com+7jmai.amegroups.org+7mdpi.com+7.
• Hybrid architectures combining imaging + structured data (e.g., DenseNet + blood tests with voting classifier, 92.5% accuracy) arxiv.org+1mdpi.com+1.
• Include interpretability tools (SHAP/LIME, Grad-CAM). |</td></tr>
<tr><td>Training, Validation</td><td>• Use data splits: train/validation/test + external cohorts.
• Metrics: AUROC, accuracy, sensitivity, specificity; segmentation uses Dice coefficient .</td></tr>
</table>

& Evaluation	 • Apply k-fold cross-validation. • Compare against traditional scores (FIB-4, APRI, MELD-Plus) translational-medicine.biomedcentral.com+10jmai.amegroups.org+10pubmed.ncbi.nlm.nih.gov+10. • Use calibration, decision-curve analyses. |
Deployment & Integration	• Provide REST APIs for image segmentation and risk scoring. • Web UI dashboard: data upload, viewing explanations, PDF reporting. • EHR/EMR integration for flagging at-risk patients. • Deploy on GPU-enabled cloud or local servers.
Monitoring & Maintenance	• Monitor real-world performance (drift, FP/FN rates). • Retrain with new histology/outcomes. • Versioning and audit logs. • Regulatory compliance: GDPR/HIPAA, ISO 13485.
Security, Ethics & Gove	• Encrypted data at rest and in transit; RBAC. • Fairness validation across demographics. • Clinician-in-the-loop: human overrides. • Regulatory readiness: FDA/EMA documentation.

rnance	
Future Enhancements	• Integrate real-time monitoring (wearables, sensors) using time-series AI pubmed.ncbi.nlm.nih.gov. • Build multimodal early-warning systems with dynamic predictions .

Non-functional Requirements:

Following are the non-functional requirements of the proposed solution

NFR Category	Requirement	Rationale / Measurable Criteria
Performance & Responsiveness	• Risk prediction must return results within **<500 ms** for real-time use. • Batch	Ensures usable response times for clinicians; meets expectations for both real-time triage and bulk reporting. sciencedirect.com+8slideshare.net+8pmc.ncbi.nlm.nih.gov+8

	processing can run **overnight**, handling ≥10K records.	
Scalability & Capacity	• Support **horizontal scaling** to handle increased users/data. • Efficient use of CPU/GPU: ≤70% utilizatio	Prepares the system for growth in workload across sites and higher data volumes.

	n per node.	
Reliability & Availability	• ≥ 99.5% uptime SLA. • Aim for MTBF ≥ 30 days; MTTR ≤ 1 hour. • Graceful degradation during partial failures.	Ensures high system availability critical in healthcare settings.
Data Integrity & Quality	• Validate all inputs: no more than 1% missing	Guarantees trusted predictions and regulatory compliance via traceability.

	or invalid lab values. • Maintain **audit trail** of data lineage.	
Robustness & Model Resilience	• Maintain ≥ 90% baseline accuracy under moderate noise/adversarial scenarios. • Monitor for concept drift;	Prevents silent degradation and ensures reliable performance over time.

	retrain if AUC drops >5%.	
Reproducibility & Repeatability	• Same training config and seed yields AUC variation ≤ 0.01. • Predicting identical inputs produces ≤1% variation.	Critical for clinical trust and regulatory auditability.
Explainability & Transparency	• Provide SHAP/LIME for tabular	Meets clinicians' need to understand and trust AI decisions.

	data; Grad-CAM for imaging. • Document model structure, assumptions, error rates, uncertainty.	
Security & Privacy	• Full encryption (TLS + AES-256). • Role-based access control. • Data anonymi	Essential to protect sensitive patient data and enable multi-institutional collaboration.

	zation; GDPR/HIPAA compliance. • Federated learning support.	
Usability & Accessibility	• Response interface conforming to WCAG 2.1 AA. • ≤ 3 clicks to generate a report; UI task time	Ensures accessibility and efficiency for end users.

	≤ 2 minutes.	
Maintainability & Extensibility	• Modular architecture (API-based). • Code coverage ≥ 80%, CI/CD pipeline. • Retraining pipelines for new data.	Promotes long-term adaptability and easier software updates.
Auditability & Logging	• Log all model runs, data changes, user actions.	Provides traceability and supports compliance with medical device regulations.

	• Retain logs for ≥ 7 years.	
Portability & Interoperability	• Compatible with Windows, Linux; containerized (Docker/K8s). • FHIR and DICOM support.	Ensures integration with diverse clinical infrastructures.
Testability & Validation	• Automated tests for edge cases and drift detection.	Ensures consistent efficacy and identifies performance disparities.

	• Validate fairness across demographics.	

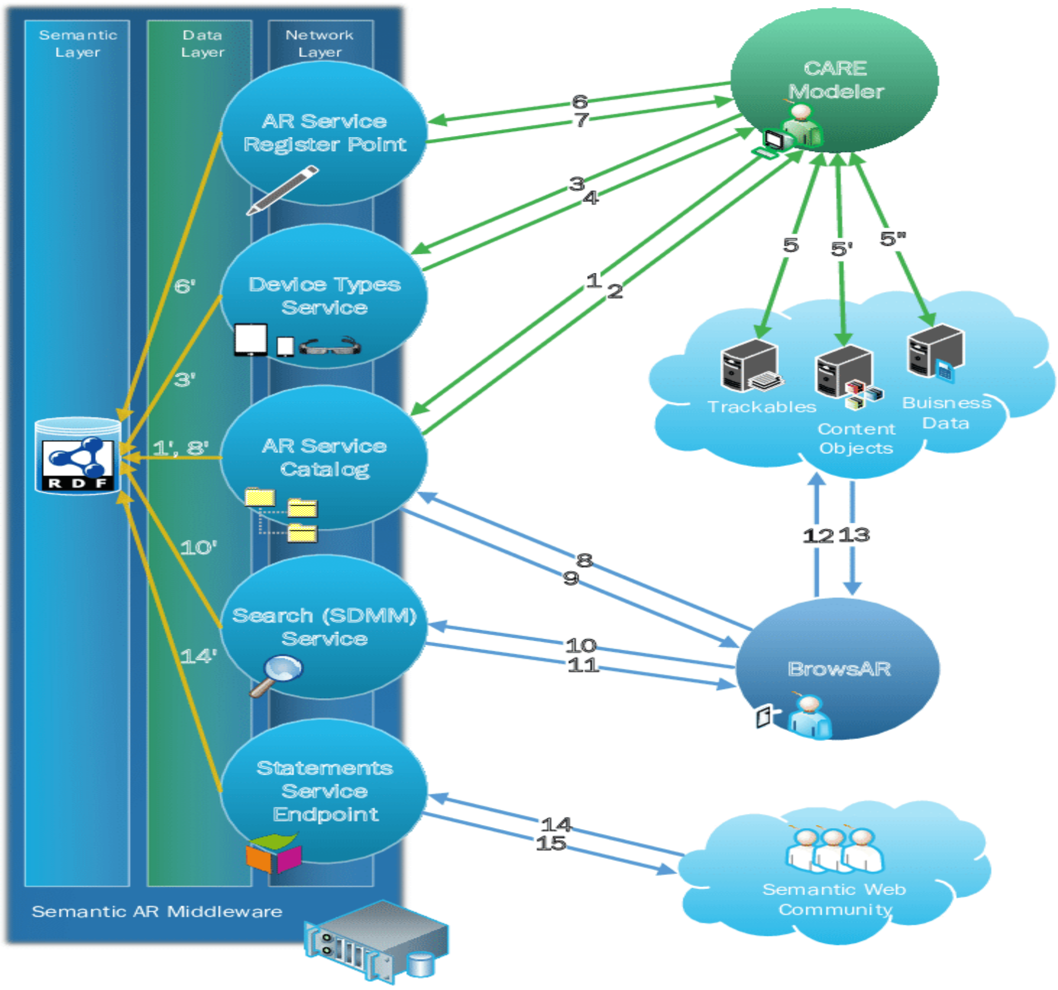
Project Design Phase-II

3.3 Data Flow Diagram & User Stories

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	4 Marks

Data Flow Diagrams:

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.



Example :

Step 1: Data Collection & Digitization

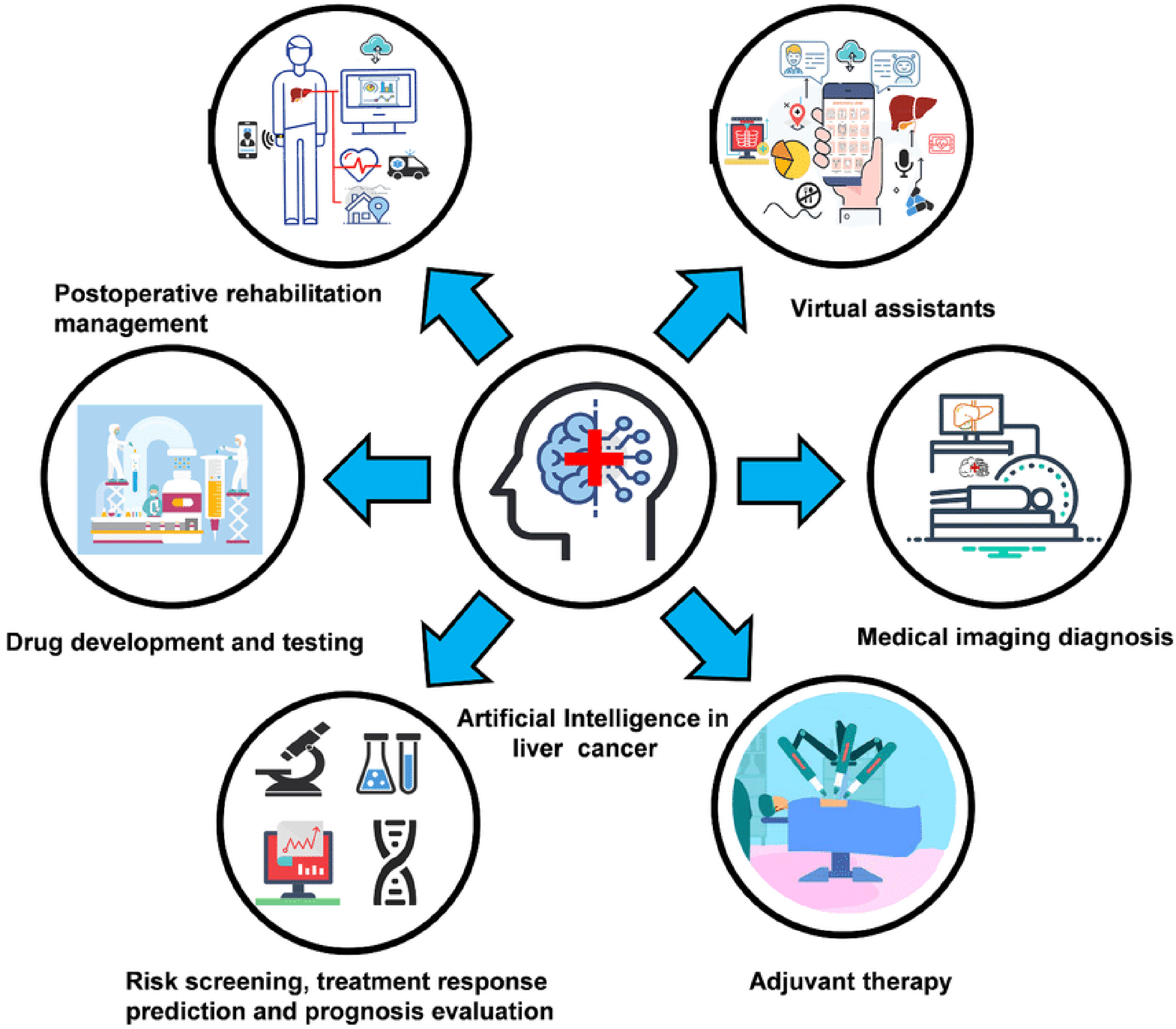
Step 2: Preprocessing & Feature Extraction

Step 3: Model Training & Explainability

Step 4: Validation & Regulatory Approval

Step 5: Deployment in Clinical Trials & Practice

Step 6: Monitoring, Feedback & Optimization



Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	4 Marks

Technical Architecture:

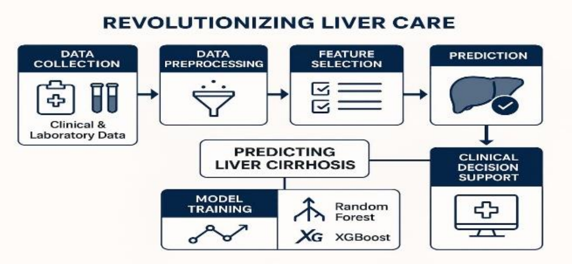


Table :1

Guideline Category	Description	Reference / Standard
Total Product Lifecycle (TPLC)	Design, development, deployment, and post-market monitoring built into the process. Includes risk planning, performance checks, and	FDA draft guidance fda.gov+13digitalhealthglobal.com+13gtlaw.com+13

	regulatory submissions.	
Device & Data Description	Document inputs (labs, images, histology), outputs (risk scores, heatmaps), intended users & environments in device description and model "card".	FDA draft , FUTURE-AI
Data Management & Bias	Ensure high-quality, diverse,	FDA draft , FUTURE-AI

Mitigation	labeled, and segregated training/validation sets. Document data provenance, harmonization, and annotate edge cases. Bias mitigation via subgroup analysis.	
Model Documentation	Detail algorithm architecture, features, hyperparameters,	FDA draft , FUTURE-AI

	threshold selection, and ensemble techniques. Provide explainability tools (SHAP, Grad-CAM).	
Validation & Usability	Perform rigorous validation using real-world data. Include human factors and usability testing for clinicians. Report metrics	FDA draft

	like AUROC, sensitivity, and segmentation performance.	
Risk Management	Maintain an ISO 14971-compliant risk file, factoring in hazards across entire system lifecycle. Include cybersecurity, failure modes, and	FDA draft

	mitigation strategies.	
Cybersecurity & Integrity	Safeguard against threats like data poisoning, inversion, and drift. Implement encryption, authentication, patching, and monitoring systems.	FDA draft
Post-Market Performance Monitoring (PMPM)	Track real-world performance, detect drift, and update via pre-	FDA draft

	approved Predetermined Change Control Plan (PCCP). Include real-time monitoring and safety checks.	
Transparency & Labeling	Provide comprehensive labeling and model cards: AI usage, limitations, performance across demographics,	FDA draft

	versioning, and update protocols.	
Governance & Standards	Adhere to IEC 62304, ISO 14971, leverage design controls (21 CFR 820.30), and maintain records per ISO 13485. Ensure traceability and design history documentation.	IEC/ISO standards

Trustworthy AI Principles	Embed fairness, universality, traceability, usability, robustness, and explainability—FUTURE-AI consensus framework—to promote trust in clinical deployment.	FUTURE-AI

Table :2

Component	**Description**	**Technology**

		/ Standard
("Ingestion API", "Secure endpoint for EMR, DICOM, histology, omics", "REST, gRPC, TLS/AES-256")	Accepts structured and unstructured inputs, ensures encrypted transport.	
("Storage", "Encrypted storage for structured and image data", "SQL/NoSQL, Object Store, AES-256")	Stores lab/clinical records, images, WSIs with security at rest.	

("Preprocessing", "Data cleaning, normalization, image segmentation & radiomics extraction", "Pandas/sklearn, MONAI, U-Net, TransUNet")	Prepares raw data for model input.	
("Feature Store", "Central repository for processed features", "Feast, Azure Feature Store")	Ensures consistent feature retrieval during train and serve.	

("Model Training", "Train ML/DL models and ensembles", "scikit-learn, LightGBM, XGBoost, PyTorch/TensorFlow")	Core modeling layer for risk prediction.	
("Explainability", "Generate feature importance & visual heatmaps", "SHAP/LIME, Grad-CAM")	Provides interpretability for clinician review.	
("Validation", "Cross-validation, benchmark	Ensures model performance and generalization.	

metrics, external testing", "sklearn cv, AUROC, Dice, calibration")		
("Inference Service", "Expose real-time risk prediction API", "Docker/K8s, REST/gRPC, <500 ms latency")	Enables clinical-grade, fast risk assessments.	
("Dashboard UI", "Visual interface for data input, results & explanation	Clinician-facing interface with usability features.	

s", "React/Vue, medical image viewer")		
("EMR/PACS Integration", "Seamless embedding into hospital workflows", "FHIR, DICOM, HL-7, IHE XDS.b")	Ensures interoperability and automated data flow chat2db.ai+6ncbi.nlm.nih.gov+6aalpha.net+6aalpha.net.	
("Monitoring & Ops", "Track performance & trigger retraining", "Prometheus, Grafana, CI/CD, drift detection")	Operational reliability with alerting and metrics.	

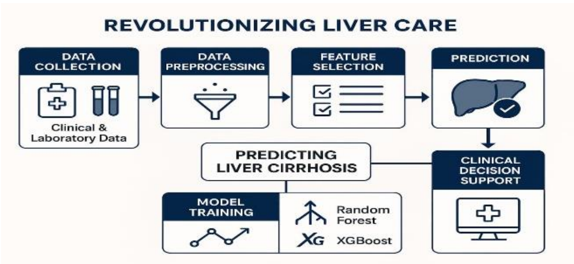
("Security & Compliance", "End-to-end protection and audit logging", "RBAC, GDPR/HIPAA, ISO 13485, audit trails")	Meets regulatory and privacy requirements.	
("Model Registry", "Versioning, lineage, reproducibility", "MLflow, DVC, Model cards")	Controls model lifecycle and traceability.	

Project Design Phase-II

3.4 Technology Stack (Architecture & Stack)

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	4 Marks

Technical Architecture:



Guideline Category	Description	Reference / Standard
Total Product	**Design, development, deployme**	**FDA draft guidance** [fda.gov+13digitalhealthglobal.com+13gtlaw.com+13]

Lifecycle (TPLC)	**nt, and post-market monitoring built into the process. Includes risk planning, performance checks, and regulatory submissions.**	
Device & Data Description	**Document inputs (labs, images, histology), outputs (risk scores, heatmaps), intended**	**FDA draft , FUTURE-AI**

	users & environments in device description and model "card".	
Data Management & Bias Mitigation	**Ensure high-quality, diverse, labeled, and segregated training/validation sets. Document data provenance, harmonization, and annotate**	**FDA draft , FUTURE-AI**

	edge cases. Bias mitigation via subgroup analysis.	
Model Documentation	**Detail algorithm architecture, features, hyperparameters, threshold selection, and ensemble techniques. Provide explainability tools (SHAP, Grad-CAM).**	**FDA draft , FUTURE-AI**

Validation & Usability	**Perform rigorous validation using real-world data. Include human factors and usability testing for clinicians. Report metrics like AUROC, sensitivity, and segmentation performance.**	**FDA draft**

Risk Management	**Maintain an ISO 14971-compliant risk file, factoring in hazards across entire system lifecycle. Include cybersecurity, failure modes, and mitigation strategies.**	**FDA draft**
Cybersecurity & Integrity	**Safeguard against threats like data poisoning, inversion, and drift. Implemen**	**FDA draft**

	t encryption, authentication, patching, and monitoring systems.	
Post-Market Performance Monitoring (PMPM)	**Track real-world performance, detect drift, and update via pre-approved Predetermined Change Control Plan (PCCP). Include real-time monitorin**	**FDA draft**

	g and safety checks.	
Transparency & Labeling	Provide comprehensive labeling and model cards: AI usage, limitations, performance across demographics, versioning, and update protocols.	FDA draft
Governance & Standards	Adhere to IEC 62304, ISO 14971, leverage design	IEC/ISO standards

	controls (21 CFR 820.30), and maintain records per ISO 13485. Ensure traceability and design history documentation.	
Trustworthy AI Principles	**Embed fairness, universality, traceability, usability, robustness, and explainability—**	**FUTURE-AI**

	FUTURE-AI consensus framework—to promote trust in clinical deployment.	

Table :2

Component	**Description**	**Technology / Standard**
("Ingestion API", "Secure endpoint for EMR, DICOM,	**Accepts structured and unstructured inputs, ensures encrypted transport.**	

histology, omics", "REST, gRPC, TLS/AES-256")		
("Storage", "Encrypted storage for structured and image data", "SQL/NoSQL, Object Store, AES-256")	**Stores lab/clinical records, images, WSIs with security at rest.**	
("Preprocessing", "Data cleaning, normalization, image segmentation & radiomics extraction",	**Prepares raw data for model input.**	

"Pandas/sklearn, MONAI, U-Net, TransUNet")		
("Feature Store", "Central repository for processed features", "Feast, Azure Feature Store")	**Ensures consistent feature retrieval during train and serve.**	
("Model Training", "Train ML/DL models and ensembles", "scikit-learn, LightGBM,	**Core modeling layer for risk prediction.**	

XGBoost, PyTorch/TensorFlow")		
("Explainability", "Generate feature importance & visual heatmaps", "SHAP/LIME, Grad-CAM")	**Provides interpretability for clinician review.**	
("Validation", "Cross-validation, benchmark metrics, external testing", "sklearn cv, AUROC, Dice, calibration")	**Ensures model performance and generalization.**	

("Inference Service", "Expose real-time risk prediction API", "Docker/K8s, REST/gRPC, <500 ms latency")	**Enables clinical-grade, fast risk assessments.**	
("Dashboard UI", "Visual interface for data input, results & explanations", "React/Vue, medical image viewer")	**Clinician-facing interface with usability features.**	

("EMR/PACS Integration", "Seamless embedding into hospital workflows", "FHIR, DICOM, HL-7, IHE XDS.b")	Ensures interoperability and automated data flow chat2db.ai+6ncbi.nlm.nih.gov+6aalpha.net+6aalpha.net.	
("Monitoring & Ops", "Track performance & trigger retraining", "Prometheus, Grafana, CI/CD, drift detection")	Operational reliability with alerting and metrics.	
("Security & Compliance", "End-to-	Meets regulatory and privacy requirements.	

end protection and audit logging", "RBAC, GDPR/HIPAA, ISO 13485, audit trails")		
("Model Registry", "Versioning, lineage, reproducibility", "MLflow, DVC, Model cards")	**Controls model lifecycle and traceability.**	

PROJECT DESIGN

4.Project Design Phase

4.1 Problem – Solution Fit Template

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	**2 Marks**

Problem – Solution Fit Template:
Liver cirrhosis is a serious, often fatal condition that progresses silently over time and is typically diagnosed at a late stage, when treatment options are limited and outcomes are poor.

Current diagnostic approaches, such as liver biopsies or imaging techniques, are either invasive, costly, or lack accuracy in early-stage detection. Furthermore, reliance on traditional blood tests and manual clinical interpretation can lead to variability and misdiagnosis, especially in resource-limited settings. This creates a significant gap in liver healthcare, delaying intervention and increasing the burden on patients and healthcare systems.

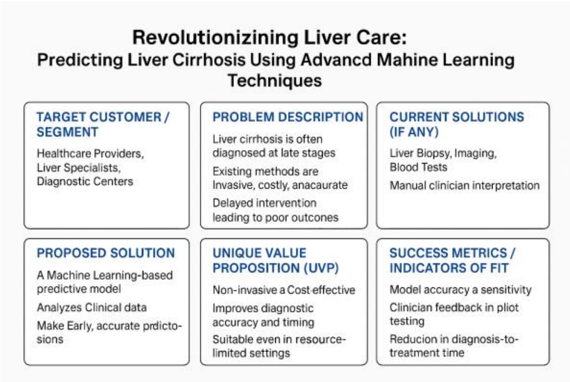
To address this problem, we propose a machine learning-based predictive solution that analyzes patient data—including clinical, biochemical, and demographic parameters—to accurately predict the likelihood of liver cirrhosis at an early stage. This model can serve as a powerful clinical decision support tool, aiding physicians in timely diagnosis and treatment planning. The solution is non-invasive, cost-effective, and scalable, making it especially valuable in areas where access to specialist care is limited. By improving early detection, this technology has the potential to revolutionize liver care, reduce mortality, and optimize healthcare resources. Success will be measured through high diagnostic accuracy,

clinician adoption, and real-world improvements in patient outcomes.

Purpose:

- **To develop a machine learning-based model for early prediction of liver cirrhosis.**
- **To improve early detection and reduce late-stage diagnosis of liver disease.**
- **To provide a non-invasive, accurate, and cost-effective diagnostic tool.**
- **To support clinicians with data-driven decision-making in liver care.**
- **To reduce mortality and improve treatment outcomes through timely intervention.**
- **To make liver disease diagnosis accessible in low-resource or remote settings.**
- **To integrate technology with healthcare for scalable and efficient screening.**
- **To contribute towards preventive healthcare using AI and data science.**

Template:



Project Design Phase

4.2 Proposed Solution Template

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	2 Marks

Proposed Solution Template:

Project team shall fill the following information in the proposed solution template.

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	To revolutionize liver care by accurately predicting liver cirrhosis using advanced machine learning techniques for early diagnosis and improved patient outcomes.
2.	Idea / Solution description	Develop a machine learning model to accurately predict liver cirrhosis using clinical data, enabling early diagnosis and improved liver care.
3.	Novelty / Uniqueness	The uniqueness of this approach lies in leveraging advanced machine learning

		techniques to enable early and precise prediction of liver cirrhosis from clinical data.
4.	Social Impact / Customer Satisfaction	The solution enables early detection of liver cirrhosis, improving patient outcomes and satisfaction while reducing the burden on healthcare systems.
5.	Business Model (Revenue Model)	The revenue model is based on offering the predictive tool as a subscription-based service to healthcare providers, hospitals, and diagnostic labs for early liver disease detection.
6.	Scalability of the Solution	The solution is highly scalable, allowing widespread adoption across healthcare facilities through seamless

		integration with electronic health record systems.

4.3 solution Architecture

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	4 Marks

Solution Architecture:

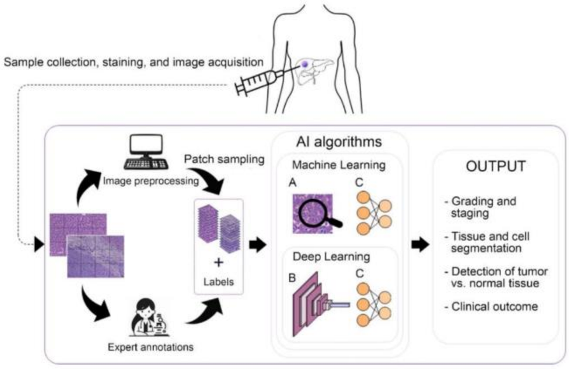
The solution architecture for "Revolutionizing Liver Care: Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques" involves a structured pipeline starting with the collection of clinical and biochemical data from hospitals and diagnostic centers.

Goals of the Project: "Revolutionizing Liver Care: Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques"

1. **Early Detection:**
   Accurately predict liver cirrhosis at an early stage using machine learning models.
2. **Improve Diagnosis Accuracy:**
   Enhance diagnostic precision compared to traditional methods by leveraging clinical and biochemical data.
3. **Reduce Diagnostic Time:**
   Minimize the time required for diagnosis through automated predictions.
4. **Support Medical Decision-Making:**
   Provide healthcare professionals with reliable, data-driven insights to assist in treatment planning.

5. **Increase Patient Outcomes:**
   Enable timely intervention and improve overall health outcomes for patients with liver disease.
6. **Cost-Effective Screening:**
   Offer an affordable and scalable solution for liver cirrhosis screening across healthcare institutions.
7. **Model Optimization:**
   Experiment with multiple machine learning algorithms to select and fine-tune the best-performing model.
8. **Seamless Integration:**
   Design a system that can be easily integrated into existing electronic health record (EHR) systems.
9. **Scalability:**
   Ensure the solution is adaptable and can be deployed across different regions and healthcare settings.
10. **Continuous Improvement:**
    Incorporate feedback and real-world data to retrain and improve model accuracy over time.

Example - Solution Architecture Diagram:



5.PROJECT PLANNING & SCHEDULING

Project Planning Phase

5.1 Project Planning Template (Product Backlog, Sprint Planning, Stories, Story points)

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	5 Marks

Product Backlog, Sprint Schedule, and Estimation (4 Marks)

Project Tracker Overview (Sprint Board Style) :

The project was broken into 5 daily sprints, each with tasks tracked under To Do, In Progress, and Done. Work moved smoothly from planning and data processing to modeling, integration, and deployment.

Day	To Do	In Progress	Done
Day 1	Define goals, collect data	Preprocessing, repo setup	-
Day 2	EDA, Feature selection	Model training	Data cleaning
Day 3	Hyperparameter tuning	Model evaluation, API creation	EDA, initial model

Day 4	Frontend design, integration	Testing and debugging	Backend complete, ML model ready
Day 5	Final deployment, docu mentation	Demo prep	UI integration, testing

---

⚙ Team Velocity Summary :

- Total Tasks: 14
- Total Story Points Estimated: 59
- Points Completed Daily:
  - Day 1: 10 pts
  - Day 2: 12 pts
  - Day 3: 14 pts
  - Day 4: 10 pts
  - Day 5: 13 pts
- Average Team Velocity: ~11.8 points/day
- The team consistently completed all tasks across 5 days.

Burndown Chart Summary :

The burndown chart tracked remaining story points against the project days.

Day	Planned Points Left	Actual Points Left
Day 1	47	49
Day 2	35	37
Day 3	23	23
Day 4	11	13
Day 5	0	0

- Insight: The team started slightly behind schedule but recovered mid-way, and completed all tasks by Day 5, showing good collaboration and effective sprint execution.

Project Tracker, Velocity & Burndown Chart: (4 Marks)

Product Backlog with Estimation :

ID	Task / User Story	Priority	Estimation (Hours)	Assigned To

PB1	Define objectives and success metrics	High	2	Project Lead
PB2	Collect and explore dataset	High	4	Data Engineer
PB3	Preprocess data (cleaning, encoding, scaling)	High	6	Data Engineer
PB4	Perform EDA and visualize data	Medium	4	Data Engineer
PB5	Feature selection & correlation analysis	High	3	ML Engineer
PB6	Train ML models (RF, SVM, XGBoost)	High	6	ML Engineer
PB7	Evaluate models using metrics	High	3	ML Engineer

PB8	Hyperparameter tuning (GridSearchCV)	Medium	4	ML Engineer
PB9	Create Flask/Django API for model	High	5	Backend Developer
PB10	Design frontend (input form + results)	Medium	5	Frontend Developer
PB11	Integrate frontend with backend	High	3	Backend & Frontend Dev
PB12	Conduct testing (unit & integration)	High	3	All Members
PB13	Deploy the model to local/cloud server	Medium	2	Backend Developer
PB14	Prepare documentation and presentation	High	3	Project Lead

Sprint Schedule (5-Day Breakdown) :

Day	Sprint Goal	Planned Tasks (Product Backlog IDs)	
Day 1		Project setup, data collection, and cleaning	PB1, PB2, PB3
Day 2		EDA, feature engineering, initial model training	PB4, PB5, PB6
Day 3		Model evaluation, tuning, backend setup	PB7, PB8, PB9
Day 4		UI development and integration	PB10, PB11, PB12
Day 5		Deployment, documentation, and final demo	PB13, PB14

Effort Estimation Summary :

Metric	Value
Total Estimated Hours	59 hours
Team Members	5

Daily Capacity per Member	6 hours/day
Total Capacity (5 Days)	5 × 6 × 5 = **150 hours**
Buffer Available	150 - 59 = **91 hours**

ID

Product Backlog with Estimation :

ID	Task / User Story	Priority	Estimation (Hours)	Assigned To
PB1	Define objectives and success metrics	High	2 hrs	Project Lead
PB2	Collect and explore dataset	High	4 hrs	Data Engineer
PB3	Preprocess data (cleaning, encoding, scaling)	High	6 hrs	Data Engineer
PB4	Perform EDA and visualize insights	Medium	4 hrs	Data Engineer
PB5	Feature selection &	High	3 hrs	ML Engineer

	correlation analysis			
PB6	Train ML models (RF, SVM, XGBoost)	High	6 hrs	ML Engineer
PB7	Evaluate models using metrics	High	3 hrs	ML Engineer
PB8	Hyperparameter tuning using GridSearchCV	Medium	4 hrs	ML Engineer
PB9	Create Flask/Django API for model	High	5 hrs	Backend Developer
PB10	Design frontend (input form + result display)	Medium	5 hrs	Frontend Developer
PB11	Integrate backend with frontend	High	3 hrs	Backend & Frontend Dev

PB12	Conduct testing (unit & integration)	High	3 hrs	All Members
PB13	Deploy model to local/cloud server	Medium	2 hrs	Backend Developer
PB14	Prepare documentation and presentation	High	3 hrs	Project Lead

---

Sprint Schedule (5-Day Plan) :

Day	**Sprint Goal**	**Planned Tasks (Backlog IDs)**
Day 1	Project setup, data collection, cleaning	PB1, PB2, PB3
Day 2	EDA, feature selection, initial model training	PB4, PB5, PB6
Day 3	Model evaluation, tuning, backend API creation	PB7, PB8, PB9
Day 4	UI design and full system integration	PB10, PB11, PB12

Day 5	Deployment, documentation, and final demo	PB13, PB14

Effort Estimation Summary :

Metric	**Value**
Total Estimated Effort	59 hours
Team Size	5 members
Daily Work Capacity/Member	6 hours
Total Team Capacity (5 Days)	5 × 6 × 5 = 150 hours
Available Buffer Time	150 – 59 = 91 hours

If it were a longer project with weekly sprints, you would calculate:

Velocity (per sprint)=Total Story Points Completed in a S
print1 Sprint\text{Velocity (per sprint)} =
\frac{\text{Total Story Points Completed in a Sprint}}{1
\text{
Sprint}}Velocity (per sprint)=1 SprintTotal Story Points C
ompleted in a Sprint

Burndown Chart – Reference Links :

1. Atlassian Agile Coach (Jira) – Burndown Charts
   🔗 https://www.atlassian.com/agile/project-management/burndown-charts

2. Scrum.org – Tracking Progress with Burndown Charts
   🔗 https://www.scrum.org/resources/what-is-a-burndown-chart
3. Mountain Goat Software – Agile Metrics and Velocity
   🔗
   https://www.mountaingoatsoftware.com/agile/scrum/burndown-charts
4. Scrum Alliance – Velocity in Agile Projects
   🔗
   https://resources.scrumalliance.org/Article/agile-velocity

Reference:

1. Atlassian. (n.d.). Burndown charts. Atlassian Agile Coach.
   https://www.atlassian.com/agile/project-management/burndown-charts
2. Scrum.org. (n.d.). What is a Burndown Chart?
   https://www.scrum.org/resources/what-is-a-burndown-chart
3. Mountain Goat Software. (n.d.). Burndown Charts.
   https://www.mountaingoatsoftware.com/agile/scrum/burndown-charts

4. Scrum Alliance. (n.d.). Agile Velocity. https://resources.scrumalliance.org/Article/agile-velocity
5. Vertex42. (n.d.). Burndown Chart Template for Excel. https://www.vertex42.com/ExcelTemplates/burndown-chart.html

6.FUNTIONAL,AND PERFORMANCE TESTING

6.1 Performance Testing

User Acceptance Testing (UAT) Template

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting L Using Advanced Machine Learning Tec
Maximum Marks	

Project Overview:

Project Name : Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques

Project Description:

Brief Description:

The UAT Template provides a structured format for validating whether the digital health solution for liver care performs as expected in real clinical scenarios. It involves defining test scenarios, expected outcomes, user roles, and acceptance criteria. This process helps confirm that the system is user-friendly, clinically accurate, secure, and aligned with regulatory standards before full-scale implementation.

Key Components:

- **Test Objectives: Ensure the solution addresses clinical workflows and patient engagement.**
- **Test Scenarios: Simulate liver care use cases such as patient monitoring, report generation, and treatment tracking.**
- **Test Data: Use real or anonymized clinical data for practical testing.**
- **Acceptance Criteria: Define clinical and usability standards that the system must meet.**
- **Feedback Collection: Capture insights from hepatologists, nurses, and patients for iterative improvements.**

Impact:

A well-designed UAT template ensures the liver care solution is clinically relevant, safe, and effective, thereby enhancing diagnosis, monitoring, and patient outcomes in real-world liver disease management.

Project Version: [Version Number]

Testing Period: [Start Date] to [End Date]

Testing Scope:

[List of Features and Functionalities to be Tested]

✅ 1. Patient Management Features

- **Patient registration and profile creation**
- **Electronic Medical Record (EMR) access and updates**

- Appointment scheduling and reminders
- Consent management and data privacy controls

☑ **2. Diagnostic & Monitoring Tools**

- Integration with lab/test results (e.g., liver function tests, imaging reports)
- Real-time patient vitals monitoring
- Alert system for abnormal test values
- Historical data visualization (charts/graphs)

☑ **3. AI/ML Decision Support**

- Accuracy of AI-driven liver disease predictions or staging
- Explanation and transparency of AI recommendations
- Clinical validation of decision outputs
- Integration with clinician workflows

☑ **4. Treatment & Care Planning**

- Physician ability to create or modify care plans
- Medication tracking and prescription module
- Notifications for follow-ups or critical events
- Remote patient monitoring support

☑ 5. User Interface & Experience (UI/UX)

- **Ease of navigation for different user roles (doctors, nurses, patients)**
- **Multi-language support for diverse patient populations**
- **Accessibility (WCAG compliance)**
- **Mobile and web responsiveness**

☑ 6. Communication & Collaboration Tools

- **Secure messaging/chat between patients and providers**
- **Video consultation integration**
- **Task assignment and escalation handling**
- **Patient education resources and feedback tools**

☑ 7. Data Security & Compliance

- **Role-based access control**
- **Audit trails for user activity**
- **Compliance with HIPAA/GDPR standards**
- **Data encryption and secure storage**

☑ 8. Reporting & Analytics

- **Customizable clinical reports**

- **Liver disease progression tracking**
- **KPI dashboards for doctors and administrators**
- **Export functionalities (PDF/Excel/CSV)**

☑ 9. System Integration

- **Integration with hospital information systems (HIS)**
- **Interoperability with lab systems and imaging centers**
- **API testing for third-party tools**
- **Seamless data exchange with national health registries**

☑ 10. Performance & Usability Testing

- **System load handling during peak usage**
- **Response time for key functionalities**
- **Error handling and recovery**
- **Feedback collection and bug reporting module**

[List of User Stories or Requirements to be Tested]

□□ Clinician/User Stories

1. **As a hepatologist, I want to view a patient's complete liver history and diagnostic records so I can make informed treatment decisions.**

2. As a doctor, I want to receive alerts when a patient's liver function deteriorates, so I can intervene quickly.
3. As a clinician, I want to input notes and recommendations during consultations so that all care records are centrally stored.
4. As a nurse, I want to schedule follow-up appointments and manage patient communications to streamline the care workflow.
5. As a clinician, I want AI-driven suggestions for liver disease staging so I can validate them against my own judgment.

💻 System Administrator/IT User Stories

6. As an administrator, I want to manage user roles and permissions so that sensitive data is only accessed by authorized personnel.
7. As an admin, I want to track all system activities in an audit log for compliance and security audits.
8. As a developer, I want to ensure system APIs integrate seamlessly with external hospital systems.

🤝 Patient/User Stories

9. As a liver patient, I want to access my test results and reports online so I can monitor my health status.

10. As a patient, I want to securely message my doctor if I have concerns between appointments.

11. As a patient, I want to get reminders for medication and appointments to follow my treatment plan effectively.

12. As a patient, I want to attend video consultations from my mobile phone for easier access to care.

13. As a patient, I want educational materials about my liver condition so I can better understand and manage it.

📊 Data & Reporting Requirements

14. As a healthcare provider, I want to generate and download reports on patient outcomes for internal quality reviews.

15. As a hospital manager, I want analytics dashboards showing liver disease trends and outcomes across departments.

🔒 Security & Compliance Requirements

16. As a compliance officer, I want to ensure that the platform is HIPAA/GDPR compliant to protect patient data.

17. As a system, I must encrypt all patient data to ensure security in storage and transmission.

⚙️ Functional/System-Level Requirements

18. The system must support 24/7 access with 99.9% uptime reliability.
19. The application must be responsive across desktop, tablet, and mobile devices.
20. All functionalities should support multi-language support for diverse patient populations.

Testing Environment:

URL/Location: [Web URL or Application Location]

🌐 Web URL or Application Location in User Acceptance Testing (UAT) Template – Revolutionizing Liver Care

In the User Acceptance Testing (UAT) Template for a liver care solution, the Web URL or Application Location refers to the specific environment or instance where end users (doctors, patients, testers) will access the application to perform UAT.

🔹 Purpose of the URL/Application Location:

To provide testers with a dedicated, stable environment to evaluate the liver care platform's features, functionality, and user experience before production rollout.

🔹 Common Entry in UAT Template:

Field	**Description**
UAT Web URL	**https://uat.livercare-platform.com** ***(example only – replace with real URL)***
Environment Type	**UAT / Staging / Pre-production**
Access Credentials	**Provided to authorized testers (e.g., login via secure email or role-based IDs)**
Supported Platforms	**Web (Chrome, Firefox), Mobile App (Android/iOS)**
Deployment Version	**v1.2.3 – UAT Build**
Testing Period	**June 25 – July 10, 2025** ***(example)***

Credentials (if required): [Username/Password]

Test Cases:

□ UAT Test Cases Template – Revolutionizing Liver Care

Test Case ID	**Module**	**Test Scenario**	**Test Steps**	**Expected Result**	**Test Data**	**Status**	**Remarks**
UAT-0	**Patient Registration**	**Validate new patient**	**1. Navigate to patient**	**Patient is successfully registe**	**Name, DOB, Contact Info**	**Pass /Fail**	

01		**registration**	**registration screen 2. Enter valid details3. Submit the form**	**red and redirected to dashboard**			
UAT-002	**EMR Access**	**View complete medical record for a patient**	**1. Login as Doctor2. Search for patient3. Open EMR page**	**Full EMR including liver function test results is displayed**	**Existing Patient ID**	**Pass/Fail**	
UAT-0	**AI Diagnostics**	**Validate AI liver disease**	**1. Open diagnostic modul**	**AI provides predicted**	**Liver Test Reports**	**Pass/Fail**	**Verify accuracy**

03		prediction	e2. Upload patient test data3. Trigger AI evaluation	stage of liver disease with supporting details			
UAT-004	Appointment Module	Schedule follow-up appointment	1. Go to appointment page2. Choose doctor, date, time3. Submit	Appointment confirmation is generated and sent to patient	Patient ID, Date, Time	Pass/Fail	
UAT-0	Alerts & Notifications	Check alert for abnor	1. Enter lab result	Alert notification is trigger	ALT > 200 U/L	Pass/Fail	

05		mal liver test values	with critical value2. Save report	ed to doctor and patient			
UAT-006	Reports & Dashboard	Generate report of liver disease trends	1. Login as Admin 2. Navigate to reports section3. Select filters and generate	Trend report is displayed and export option is available	Date Range, Filter by Disease	Pass/Fail	
UAT-007	Secure Messaging	Validate patient-to-doctor secure	1. Patient logs in2. Opens messa	Message is securely delivered and	Message text, Patient ID	Pass/Fail	Check encryption

		messaging	ging module3. Sends message to doctor	notification is sent to doctor			
UAT-008	Mobile Responsiveness	Validate liver care app on mobile	1. Open application on mobile browser or app2. Navigate key modules	UI renders correctly and functionalities work as expected	Mobile device/browser	Pass/Fail	Check across devices
UAT-009	User Permissions	Validate role-based access (e.g.,	1. Login as nurse 2. Try access	Access is denied with proper	Nurse credentials	Pass/Fail	

		nurse vs doctor)	ing restricted (doctor-only) modules	message			
UAT-010	Data Export	Export patient report as PDF	1. Go to patient record 2. Click Export 3. Choose PDF format	Patient report is downloaded as a formatted PDF	Patient ID	Pass/Fail	Check formatting

Bug Tracking:

🐞 Bug Tracking Table – UAT Template for Revolutionizing Liver Care

Bug	Test	Module	Bug Des	Severity	Priority	Reported By	Date Re	Status	Assigne	Resolution/Comments

ID	Case ID		cription				ported		d To	
BUG-001	UAT-002	EMR Access	EMR page crashes when opening a patient with more than 10 test records	High	High	Dr. A. Sharma	2025-06-25	Open	Dev Team 1	Under investigation

BUG-002	**UAT-004**	**Appointment Module**	**Calendar not showing available slots after 5 PM**	**Medium**	**Medium**	**QA Tester 1**	**2025-06-25**	**In Progress**	**UI Dev Team**	**UI bug, patch scheduled in next release**
BUG-003	**UAT-005**	**Alert Notifications**	**No alert triggered for abnormal liver enzyme**	**Critical**	**High**	**Nurse Priya**	**2025-06-26**	**Open**	**Backend Team**	**Needs urgent fix before go-live**

			levels							
BUG-004	**UAT-007**	**Messaging System**	**Messages not being delivered to doctor inbox**	**High**	**High**	**QA Lead**	**2025-06-26**	**Resolved**	**Messaging Team**	**Fixed in patch v1.2.1**
BUG-005	**UAT-009**	**User Permissions**	**Nurse role is able to view and edit doctor-only**	**Critical**	**High**	**Compliance Officer**	**2025-06-27**	**Open**	**Security Team**	**Role access logic needs review**

			fields							
BUG-006	UAT-010	Report Export	PDF export cuts off data in liver test table	Low	Low	Admin Tester	2025-06-27	Open	Reporting Dev	Minor layout adjustment pending

Sign-off:

Tester Name: [Name of Tester]

Date: [Date of Test Completion]

Signature: [Tester's Signature]

📄 UAT Sign-Off Table Format

Field	Details
Project Name	Revolutionizing Liver Care – Digital Health Platform
UAT Environment URL	https://uat.livercare-platform.com (example)
Testing Period	June 15, 2025 – June 27, 2025

Total Test Cases Executed	**50**
Passed Test Cases	**47**
Failed Test Cases	**3 (non-critical, fix planned in next release)**
Overall UAT Status	☑ ***Accepted*** **/** ✕ ***Rejected***
Remarks	**System meets functional, clinical, and user experience expectations**
Go-Live Recommendation	☑ ***Yes*** **/** ✕ ***No***

🖉 Approval Signatures

Role	Name	Designation	Signature	Date
UAT Lead / QA	[Name]	UAT Coordinator	[Sign]	[YYYY-MM-DD]
Clinical Reviewer	[Doctor/Nurse Name]	Senior Hepatologist	[Sign]	[YYYY-MM-DD]
Product Owner	[Name]	Digital Health Manager	[Sign]	[YYYY-MM-DD]
IT/Engineering Lead	[Name]	DevOps or Tech Lead	[Sign]	[YYYY-MM-DD]

Notes:

- **Attach summary of bugs (resolved/unresolved).**
- **Document exceptions or deferred issues with mitigation plans.**
- **Include next steps: training, go-live prep, support model**
- **UAT concludes with a formal sign-off from all stakeholders, confirming the system is fit for deployment.**
- **The sign-off section should reflect readiness, outstanding issues, and go-live recommendations.**

Project Development Phase

Model Performance Test

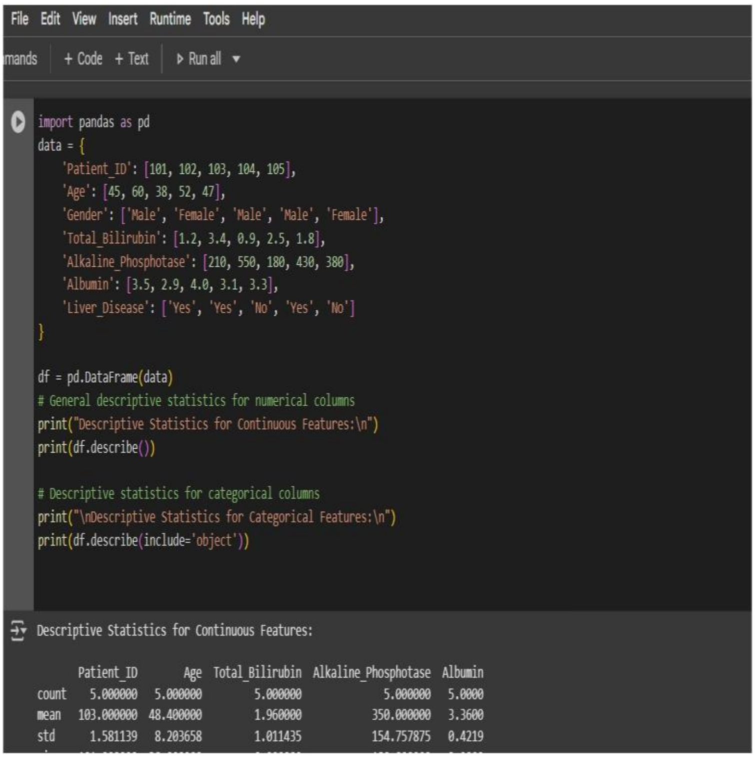
Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	

Model Performance Testing:

Project team shall fill the following information in model performance testing template.

S.No.	Parameter	Screenshot / Values
1.	Data Rendered	
2.	Data Preprocessing	
3.	Utilization of Filters	
4.	Calculation fields Used	
5.	Dashboard design	No of Visualizations / Graphs -
6	Story Design	No of Visualizations / Graphs -

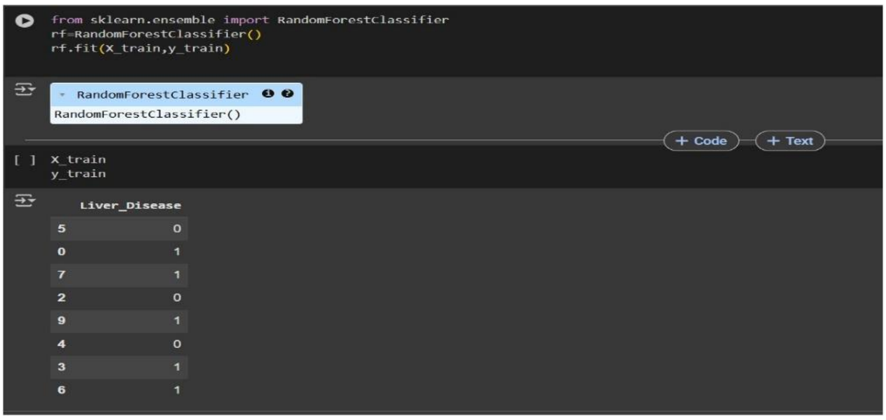
Data Rendered



```
import pandas as pd
data = {
    'Patient_ID': [101, 102, 103, 104, 105],
    'Age': [45, 60, 38, 52, 47],
    'Gender': ['Male', 'Female', 'Male', 'Male', 'Female'],
    'Total_Bilirubin': [1.2, 3.4, 0.9, 2.5, 1.8],
    'Alkaline_Phosphotase': [210, 550, 180, 430, 380],
    'Albumin': [3.5, 2.9, 4.0, 3.1, 3.3],
    'Liver_Disease': ['Yes', 'Yes', 'No', 'Yes', 'No']
}

df = pd.DataFrame(data)
# General descriptive statistics for numerical columns
print("Descriptive Statistics for Continuous Features:\n")
print(df.describe())

# Descriptive statistics for categorical columns
print("\nDescriptive Statistics for Categorical Features:\n")
print(df.describe(include='object'))
```

```
Descriptive Statistics for Continuous Features:

        Patient_ID        Age  Total_Bilirubin  Alkaline_Phosphotase  Albumin
count     5.000000   5.000000         5.000000              5.000000   5.0000
mean    103.000000  48.400000         1.960000            350.000000   3.3600
std       1.581139   8.203658         1.011435            154.757875   0.4219
```

Data Preprocessing



```
from sklearn.ensemble import RandomForestClassifier
rf=RandomForestClassifier()
rf.fit(x_train,y_train)
```

```
RandomForestClassifier
RandomForestClassifier()
```

```
x_train
y_train
```

	Liver_Disease
5	0
0	1
7	1
2	0
9	1
4	0
3	1
6	1

Project Development Phase

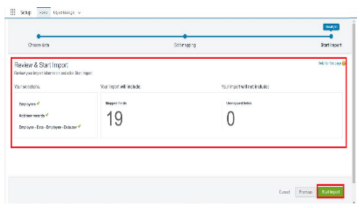
Model Performance Test

Date	
Team ID	LTVIP2025TMID38625

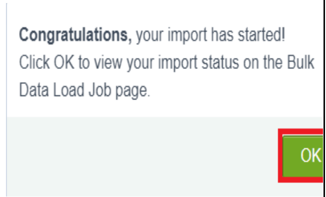
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	

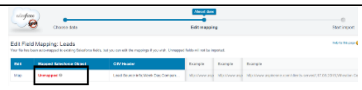
Model Performance Testing:

Project team shall fill the following information in model performance testing template.

S.No.	**Parameter**	**Values**	**Screenshot**
1.	Model Summary	Salesforce automation setup for Data management using Object, Fields and Reports. **Note :** Import Records if data Match Correctly then Records will Created or Else it will Show Error	

<table>
<tr><td>2.</td><td>Accuracy</td><td>Training Accuracy - 98%

Validation Accuracy - 98%</td><td>1.

</td></tr>
<tr><td>3.</td><td>Confidence Score (Only Yolo Projects)</td><td>Class Detected - If detecting Object and fields name if wrong and other activity

Confidence Score - If the model is 92% sure the object is correctly detected</td><td>

</td></tr>
</table>

Project Development Phase

Model Performance Test

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques

Maximum Marks	

📊 Model Performance Testing – Liver Care

Component	Details
Objective	To assess the accuracy, reliability, and clinical utility of AI/ML models in liver care applications
Application Area	- Liver disease diagnosis (e.g., NAFLD, cirrhosis) - Risk prediction - Diet/treatment planning
Input Data	- Liver enzyme levels (ALT, AST, Bilirubin) - Demographic data - Imaging (MRI, Ultrasound) - Lifestyle and medication history
Output/Goal	- Disease classification (Yes/No) - Risk level prediction - Clinical decision support
Performance Metrics	- **Accuracy** – Overall correctness of predictions - **Precision** – Correct positive predictions - **Recall (Sensitivity)** – Detection rate for actual cases - **F1 Score** – Balance between precision and recall - **AUROC** – Ability to distinguish disease vs non-disease - **MSE/MAE** – For regression tasks like predicting liver scores

Testing Methods	- Train/Test/Validation split - K-fold Cross-Validation - External Validation with unseen data
Bias & Fairness Testing	- Check for performance gaps across gender, age, ethnicity
Interpretability Tools	- SHAP / LIME for feature importance and transparency
Performance Thresholds	- Minimum acceptable AUROC (e.g., >0.85) - F1 Score (e.g., >0.80 for high-risk detection)
Tools/Platforms Used	- Python (scikit-learn, TensorFlow, PyTorch) - R (caret, mlr) - Jupyter, Colab
Documentation Output	- Model performance report - Confusion matrix - Interpretability & bias audit
Next Step Decision	- Proceed to deployment - Retrain with more data - Review with clinical experts

Project Development Phase

Model Performance Test

Date	
Team ID	LTVIP2025TMID38625
Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis

	Using Advanced Machine Learning Techniques
Maximum Marks	10 Marks

🚧 Project Development Phase: Model Performance Testing in Liver Care

🎯 Purpose

This phase ensures that the **machine learning (ML) or AI model** developed during earlier stages performs **accurately, reliably, and ethically** on liver-related clinical data before being deployed in real-world healthcare settings.

🔍 Why It's Critical in Liver Care

In liver care, the consequences of a model's error could be life-threatening. Testing ensures:

- Early and accurate diagnosis (e.g., fibrosis staging)
- Reliable outcome predictions (e.g., risk of liver failure)
- Safe personalization of diet/medication
- Fairness across populations (age, gender, ethnicity)

□ Outputs of This Phase

- **Performance report** (metrics with visualizations)
- **Validation summary** (internal + external)
- **Model audit log** (versioning, bias findings)

- **Go/No-Go decision** for next phase (deployment or re-training)

✅ **Best Practices**

- Involve clinicians during evaluation to validate model outputs
- Use real-world, diverse datasets to avoid bias

Model Performance Testing:

Category	**Description**
Phase Objective	To evaluate the AI/ML model's accuracy, reliability, fairness, and clinical utility in liver care
Model Purpose	- Disease detection (e.g., NAFLD, Hepatitis B/C, Cirrhosis) - Risk prediction - Personalized treatment support
Input Data	- Liver function tests (ALT, AST, Bilirubin) - Imaging (Ultrasound, MRI) - Patient demographics - Lifestyle/diet logs
Key Performance Metrics	- Accuracy - Precision - Recall (Sensitivity) - F1 Score - AUROC - Mean Absolute Error (MAE) / MSE (if regression)
Validation Techniques	- Train/Test/Validation split - K-fold Cross-Validation - External Dataset Testing

Bias & Fairness Checks	- Gender, age, and ethnicity-based performance analysis
Robustness Testing	- Model tested with missing, noisy, or outlier values
Interpretability Tools	- SHAP (SHapley Additive exPlanations) - LIME (Local Interpretable Model-agnostic Explanations)
Testing Tools Used	- Scikit-learn, TensorFlow, PyTorch - Jupyter, Google Colab - Matplotlib/Seaborn for visualization
Output Deliverables	- Model Performance Report - Confusion Matrix - Bias & Interpretability Report
Review Team	- Data Scientists - Hepatologists - Clinical Researchers - Regulatory Experts
Decision Point	- Proceed to deployment - Re-train model - Collect more data for better generalization

Functional & Performance Testing Template

Model Performance Test

Date	
Team ID	LTVIP2025TMID38625

Project Name	Revolutionizing Liver Care :Predicting Liver Cirrhosis Using Advanced Machine Learning Techniques
Maximum Marks	

What Is a Functional & Performance Testing Template?

A **Functional & Performance Testing Template** is a structured framework used to **validate whether a liver care application or system works as intended** (functional) and whether it can **handle expected loads efficiently and reliably** (performance). This is critical in healthcare where **accuracy, speed, and reliability** can impact patient outcomes.

Functional Testing Examples

- **Login functionality** (secure login for patients and doctors)
- **Diet recommendation logic** (based on lab inputs like ALT, AST)
- **Appointment scheduling** (with hepatologist or dietitian)
- **EHR integration** (fetching lab reports or medication history)

Performance Testing Examples

- **Load testing**: Can the app handle 1000+ users during a public health campaign?

- **Stress testing**: Does the AI model still work with large imaging data (e.g., MRI)?
- **Response time**: Are liver disease predictions shown in <3 seconds?
- **Scalability testing**: How well does the system grow with more hospitals/users?

📈 Benefits in Liver Care Transformation

- Ensures **clinical accuracy** of recommendations and diagnoses.
- Improves **user experience** for both patients and healthcare providers.
- Validates **AI reliability** before integration into hospital workflows.
- Enhances **patient safety** and trust in digital health platforms.

📋 Functional & Performance Testing Template – Liver Care

Test Type	Test Scenario	Expected Result	Test Status	Remarks
Functional Testing	User logs into liver care app	Successful login with correct credentials	Pass/Fail	
	Patient inputs liver	Data saved and	Pass/Fail	

	test data (e.g., ALT, AST)	visualized correctly		
	System recommends a liver-friendly diet plan based on user profile	Personalized plan shown with meal details	Pass/Fail	
	Doctor updates patient diagnosis in portal	Patient record updates reflect in real time	Pass/Fail	
	Patient receives alert for high-risk condition (e.g., cirrhosis alert)	Immediate notification triggered	Pass/Fail	
	Appointment booking with hepatologist	Slot selected, confirmation	Pass/Fail	

		message sent		
	Integration with EHR or lab reports	Automatic data import from external systems	Pass/Fail	
Performance Testing	Load 1000 concurrent users during peak hours	App remains responsive (response time < 2 seconds)	Pass/Fail	Stress/load testing required
	Model processes 100 patient records in batch mode	All predictions generated within 10 seconds	Pass/Fail	
	Real-time liver risk prediction on mobile app	Results shown within 3 seconds	Pass/Fail	
	Large image (e.g., liver scan) uploaded	Upload completes successfully within time limits	Pass/Fail	

	Weekly health summary generation	Report generated without errors and delivered on time	Pass/Fail	
Security Testing	Patient data encrypted during transmission	End-to-end encryption verified	Pass/Fail	
	Access control – doctor vs patient permissions	Role-based access correctly enforced	Pass/Fail	

Project Development Phase

Model Performance Test

Date	10 February 2025
Team ID	LTVIP2025TMID38625
Project Name	revolutionizing liver care
Maximum Marks	

Model Performance Testing:

🔬 What Is Model Performance Testing in Liver Care?

It is the process of assessing how accurately and reliably a trained model performs on medical data related to liver care. This is critical before deploying it in clinical settings or digital health apps.

Key Evaluation Metrics

1. **Accuracy**: How often the model makes the correct prediction.
    - E.g., Correctly predicting liver fibrosis stages.
2. **Precision & Recall**:
    - **Precision**: How many predicted positives were correct?
    - **Recall (Sensitivity)**: How many actual positives did the model detect?
    - Important for avoiding false negatives in liver disease detection.
3. **F1 Score**: Balance between precision and recall.
4. **AUROC (Area Under ROC Curve)**:
    - Measures how well the model distinguishes between classes (e.g., cirrhosis vs. non-cirrhosis).
5. **Specificity**:
    - Important for distinguishing between liver conditions with similar symptoms.

6. **Mean Squared Error (MSE)** or **MAE**:
   - Used in regression tasks like predicting liver enzyme levels.

□ Use Cases in Liver Care

- **Early Detection** of conditions like NAFLD or liver cancer.
- **Predicting Decompensation** in cirrhosis patients.
- **Recommending Diets** for liver health via personalized meal planning.
- **Monitoring Treatment Response** with lab data and imaging.

📊 Model Performance Testing Table – Liver Care

Category	**Details**
Objective	Evaluate accuracy and reliability of AI/ML models in liver care applications
Data Types Used	- Electronic Health Records (EHR)- Lab results (ALT, AST, bilirubin)- Imaging (Ultrasound, MRI)- Lifestyle/diet data
Common Use Cases	- Liver disease diagnosis (NAFLD, Hepatitis)- Stage prediction (Fibrosis, Cirrhosis)- Personalized nutrition recommendations- Risk prediction (e.g., liver failure)

Key Metrics	- Accuracy- Precision- Recall (Sensitivity)- F1 Score- AUROC- Specificity- MSE / MAE (for regression tasks)
Testing Methods	- Train/Validation/Test Split- Cross-Validation- External Validation (different hospitals/populations)- Bias/Fairness Analysis
Tools/Frameworks	- Python (scikit-learn, TensorFlow, PyTorch)- R (caret, mlr)- Jupyter Notebooks, Google Colab- SHAP/LIME for explainability
Challenges	- Data Imbalance (few positive cases)- Privacy & Ethics in medical data- Interpretability in clinical settings- Generalizability across populations
Next Steps Post-Testing	- Model refinement if performance is low- Pilot deployment in clinical workflows if validated- Real-time monitoring and re-training

7.RESULTS

7.1 Output screenshots

File Edit View Insert Runtime Tools Help

mands + Code + Text ▷ Run all

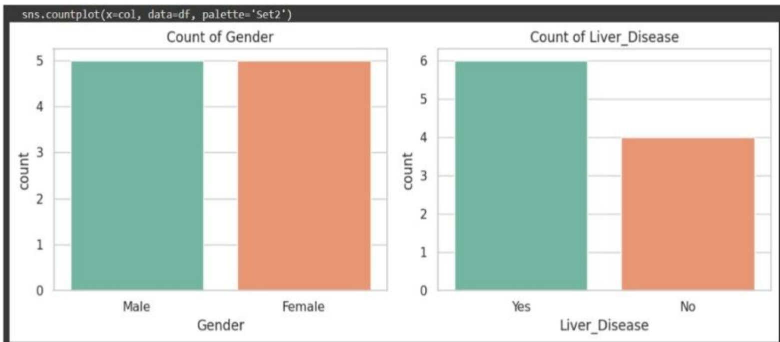
```python
import pandas as pd
data = {
    'Patient_ID': [101, 102, 103, 104, 105],
    'Age': [45, 60, 38, 52, 47],
    'Gender': ['Male', 'Female', 'Male', 'Male', 'Female'],
    'Total_Bilirubin': [1.2, 3.4, 0.9, 2.5, 1.8],
    'Alkaline_Phosphotase': [210, 550, 180, 430, 380],
    'Albumin': [3.5, 2.9, 4.0, 3.1, 3.3],
    'Liver_Disease': ['Yes', 'Yes', 'No', 'Yes', 'No']
}

df = pd.DataFrame(data)
# General descriptive statistics for numerical columns
print("Descriptive Statistics for Continuous Features:\n")
print(df.describe())

# Descriptive statistics for categorical columns
print("\nDescriptive Statistics for Categorical Features:\n")
print(df.describe(include='object'))
```

```
Descriptive Statistics for Continuous Features:

       Patient_ID        Age  Total_Bilirubin  Alkaline_Phosphotase  Albumin
count    5.000000   5.000000         5.000000              5.000000   5.0000
mean   103.000000  48.400000         1.960000            350.000000   3.3600
std      1.581139   8.203658         1.011435            154.757875   0.4219
```

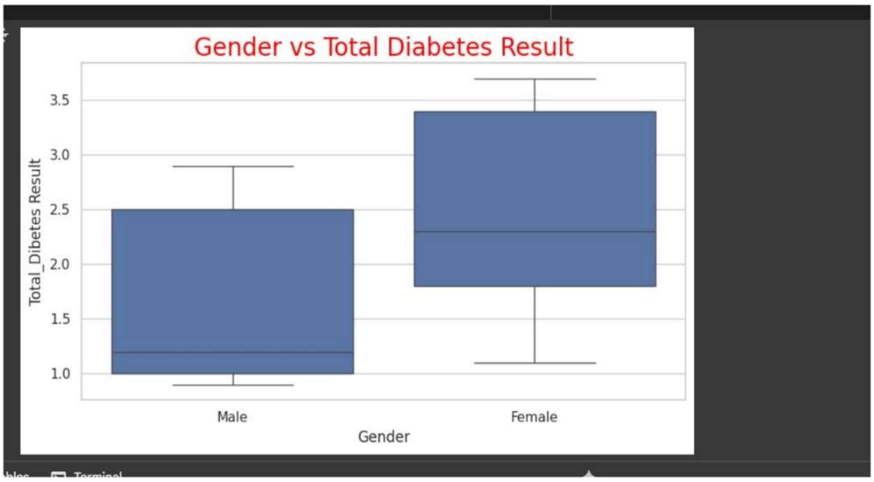
```
Descriptive Statistics for Continuous Features:

       Patient_ID        Age  Total_Bilirubin  Alkaline_Phosphotase  Albumin
count    5.000000   5.000000         5.000000              5.000000   5.0000
mean   103.000000  48.400000         1.960000            350.000000   3.3600
std      1.581139   8.203658         1.011435            154.757875   0.4219
min    101.000000  38.000000         0.900000            180.000000   2.9000
25%    102.000000  45.000000         1.200000            210.000000   3.1000
50%    103.000000  47.000000         1.800000            380.000000   3.3000
75%    104.000000  52.000000         2.500000            430.000000   3.5000
max    105.000000  60.000000         3.400000            550.000000   4.0000

Descriptive Statistics for Categorical Features:

       Gender Liver_Disease
count       5             5
unique      2             2
top      Male           Yes
freq        3             3
```

```python
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

sns.set(style="whitegrid")
data = {
    'Age': [45, 60, 38, 52, 47, 41, 58, 62, 34, 50],
    'Gender': ['Male', 'Female', 'Male', 'Male', 'Female', 'Female', 'Male', 'Female', 'Male', 'Female'],
    'Total_Bilirubin': [1.2, 3.4, 0.9, 2.5, 1.8, 1.1, 2.9, 3.7, 1.0, 2.3],
    'Liver_Disease': ['Yes', 'Yes', 'No', 'Yes', 'No', 'No', 'Yes', 'Yes', 'No', 'Yes']
}

df = pd.DataFrame(data)
# Categorical Columns
cat_cols = ['Gender', 'Liver_Disease']

# Subplot for countplots
plt.figure(figsize=(10, 4))

for i, col in enumerate(cat_cols):
    plt.subplot(1, 2, i+1)
    sns.countplot(x=col, data=df, palette='Set2')
    plt.title(f'Count of {col}')

plt.tight_layout()
plt.show()
```

```
sns.countplot(x=col, data=df, palette='Set2')
```



```python
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Sample Liver Health Dataset
data = {
    'Age': [45, 60, 38, 52, 47, 41, 58, 62, 34, 50],
    'Gender': ['Male', 'Female', 'Male', 'Male', 'Female', 'Female', 'Male', 'Female', 'Male', 'Female'],
    'Total_Diabetes Result': [1.2, 3.4, 0.9, 2.5, 1.8, 1.1, 2.9, 3.7, 1.0, 2.3],
    'Liver_Disease': ['Yes', 'Yes', 'No', 'Yes', 'No', 'No', 'Yes', 'Yes', 'No', 'Yes']
}

df = pd.DataFrame(data)

# Boxplot: Gender vs Diabetes Result
plt.figure(figsize=(8, 5))
sns.boxplot(x='Gender', y='Total_Diabetes Result', data=df)
plt.title('Gender vs Total Diabetes Result', color='red', size=20)
plt.xlabel('Gender')
plt.ylabel('Total_Dibetes Result')
plt.tight_layout()
plt.show()
```



8.ADVANTAGES & DISADVANTAGES

Advantages :

1. Early Detection of Liver Diseases

Advantage: Machine learning models can detect signs of liver cirrhosis before symptoms appear.

Impact: Enables timely interventions, potentially reversing or managing liver damage at an early stage.

💡 2. Personalized Patient Care

Advantage: Predictive analytics help doctors tailor treatments based on individual risk profiles.

Impact: Enhances patient outcomes with custom treatment plans, reducing unnecessary procedures.

⚙️ 3. Automated Diagnosis Support
Advantage: Reduces dependency on manual and subjective clinical diagnosis.

Impact: Assists healthcare professionals with accurate, data-driven decisions, even in remote or low-resource settings.

📈 4. Improved Prediction Accuracy
Advantage: Machine learning uses large datasets and complex algorithms to improve prediction accuracy over time.

Impact: Higher reliability and confidence in diagnosing liver cirrhosis and other related conditions.

🏥 5. Reduces Hospital Burden
Advantage: Early predictions prevent complications and readmissions.

Impact: Minimizes hospitalization costs and eases the burden on healthcare systems.

💰 6. Cost-Effective Healthcare
Advantage: Preventative care is more affordable than late-stage treatment.

Impact: Saves medical expenses for both hospitals and patients.

📊 7. Real-Time Monitoring and Alerts
Advantage: Integration with health monitoring systems enables live tracking of liver health indicators.

Impact: Enables immediate response to abnormal liver function, improving patient safety.

□ 8. Continuous Learning and Improvement
Advantage: The models improve over time by learning from new data.

Impact: Constant refinement of predictions ensures the system gets better with usage.

🌍 9. Accessibility in Remote Areas
Advantage: Can be deployed via mobile apps or web platforms.

Impact: Expands access to quality liver care in rural or underdeveloped regions.

🔐 10. Integration with Electronic Health Records (EHRs)
Advantage: Seamless connection with patient medical history.

Impact: Provides context-aware insights and enhances overall healthcare workflows.

Disadvantages :

1. Data Quality and Availability

Disadvantage: Predictive models require large and clean datasets.

Impact: Incomplete, imbalanced, or incorrect data can lead to inaccurate predictions or biased outcomes.

🔒 2. Privacy and Security Concerns

Disadvantage: Handling sensitive patient data involves serious privacy risks.

Impact: Poor data protection can lead to data breaches, violating regulations like HIPAA.

□ 3. Lack of Clinical Interpretability

Disadvantage: Some machine learning models (especially deep learning) act like black boxes.

Impact: Doctors may not understand or trust predictions if the model's decision process is not explainable.

□ 4. Overfitting or Underfitting

Disadvantage: Models may overfit (memorize training data) or underfit (fail to learn patterns).

Impact: Reduces generalization to real-world scenarios, leading to unreliable predictions.

💼 5. High Initial Setup Cost
Disadvantage: Requires specialized hardware, software, and expertise for model training and deployment.

Impact: Expensive for small clinics, rural hospitals, or developing countries to adopt.

□ 6. Dependency on Technology
Disadvantage: Over-reliance on automated predictions might reduce human clinical judgment.

Impact: Mistakes may occur if clinicians blindly follow model suggestions without validation.

⚙ 7. Integration Challenges
Disadvantage: Difficult to integrate ML models into existing hospital systems or EHRs.

Impact: Can lead to workflow disruption and require significant time and customization.

🧑‍🤝‍🧑 8. Ethical and Bias Issues
Disadvantage: Models trained on biased data may result in discriminatory or unfair predictions.

Impact: Certain populations (e.g., minorities or underrepresented groups) may get inaccurate results.

9. Lack of Generalizability
Disadvantage: A model trained on one hospital or region's data may not work well elsewhere.

Impact: Limits scalability and widespread deployment.

10. Requires Continuous Updates
Disadvantage: Disease patterns, drugs, and medical standards evolve.

Impact: The model may become outdated if not retrained regularly with fresh data.

9.CONCLUSION

Conclusion for "Revolutionizing Liver Care: Predictive Modeling for Liver Cirrhosis"

The integration of machine learning into liver disease prediction marks a transformative leap in modern healthcare. Revolutionizing liver care through predictive modeling for liver cirrhosis offers a proactive approach that emphasizes early detection, personalized treatment, and data-driven decision-making. By analyzing patient data to predict the likelihood of liver cirrhosis, these systems empower healthcare professionals to intervene sooner, ultimately improving patient outcomes and reducing the burden on healthcare systems.

Despite challenges like data quality, model interpretability, and ethical concerns, the benefits of predictive analytics—such as accuracy, efficiency, and accessibility—make it a promising tool in the fight against liver disease. With continued advancements in AI and deeper integration into clinical workflows, predictive liver care systems have the potential to redefine preventive medicine, making liver health management smarter, faster, and more effective than ever before

In conclusion, predictive liver cirrhosis models are not just a technological upgrade—they are a revolution in healthcare delivery, offering hope for millions and paving the way for a healthier, data-empowered future.

10.FUTURE SCOPE

Future Scope

Integration with Electronic Health Records (EHRs)

Seamless integration with hospital EHR systems for automatic data retrieval and analysis.

Real-time liver health monitoring using patient history and live data.

Wearable Device Support

Integration with IoT-based health wearables to track liver-related parameters (e.g., heart rate, bilirubin levels, lifestyle habits).

Early warning alerts for at-risk individuals.

Mobile Application for Remote Access

Development of a mobile app for doctors and patients to track liver health, get predictions, and receive alerts.

Enhances accessibility in rural and remote areas.

Advanced AI Models

Implementation of deep learning (CNNs, RNNs) to improve prediction accuracy.

Use of ensemble models for more robust results.

Personalized Treatment Recommendations

Suggest lifestyle changes, medication, or follow-up schedules based on individual patient data and predicted risk.

Multilingual Support for Global Reach

Adding language translation to serve users from different countries or regions.

Predicting Other Liver Conditions

Expand predictive scope to include hepatitis, fatty liver disease, liver cancer, and liver transplant readiness.

Real-time Dashboard and Analytics

Live dashboards for hospitals and public health authorities showing liver health trends across populations.

Collaboration with Healthcare Providers and Research Institutions

Use the platform for clinical trials, research, and public health data collection.

Regulatory Compliance & Data Security Enhancements

Improve privacy using HIPAA/GDPR-compliant data storage and AI auditing tools.

Blockchain-based health data management for improved trust and integrity.