Annexure-III

EchoCare:
A Low-Cost AI-Enhanced Digital Stethoscope

Applicants:
Ishanya 21329
Rehan 220502
Devashish Tripathi 21093

Faculty Advisor: Dr Haroon R Lone
Department of EECS
IISER Bhopal

IICE

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PROBLEM: THE GLOBAL BURDEN

- Cardiovascular diseases remain the leading global cause of mortality, responsible for an estimated **20.5 million deaths in 2021**, over **30% of all deaths worldwide** (WHF, 2021).

- In accordance with the WHO, India accounts for **one-fifth of these deaths** worldwide especially in younger population. The results of Global Burden of Disease study state age-standardized CVD death rate of 272 per 100,000 population in India which is much higher than that of global average of 235.

Challenges in Rural Healthcare Access

- 70% of India's population lacks access to healthcare specialists.
- Only 13% have access to primary health centers.

"Reading a technically poor echocardiogram is like looking at a polar bear in a snow storm."
—Lynn Y. Zoiopoulos, DO

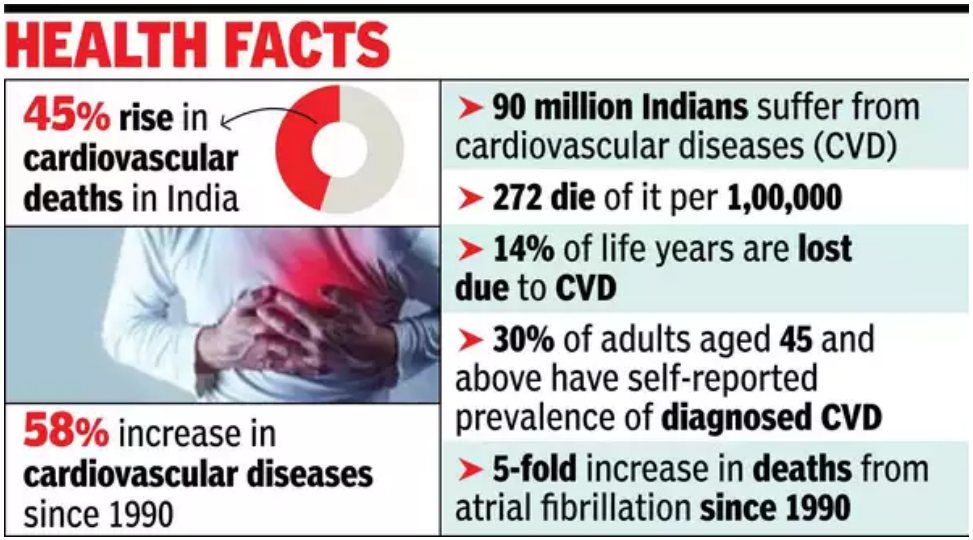

Fig: ToI Article on CVDs, dated: Sept 29, 2024

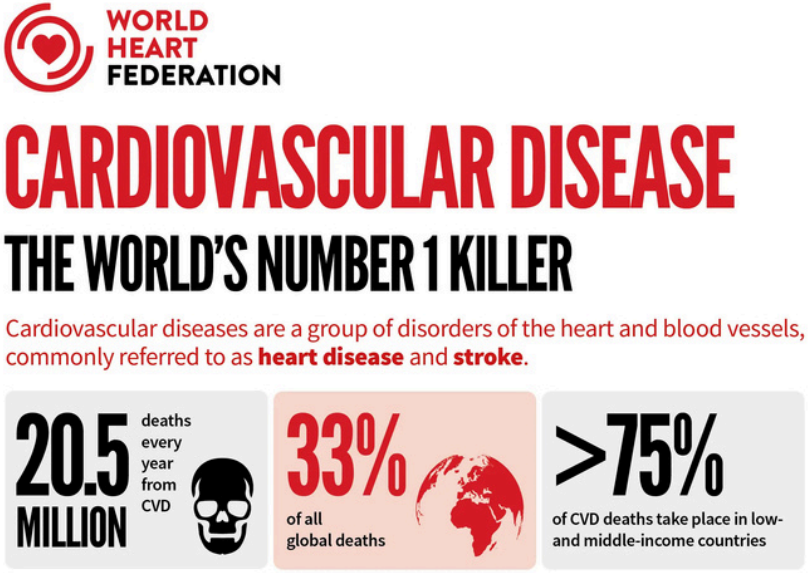

Fig: Poster by WHF on CVDs

OPPORTUNITY:
WHERE ARE WE FALLING SHORT!?

Preventable but Persistent Crisis

75% of CVD-related deaths are preventable through early detection and timely intervention (WHF, 2021).

Barriers:

1. **Shortage of specialists** and reliance on expertise for **early diagnosis**.
2. Lack of **affordable diagnostic** tools in rural and underserved regions.
3. **Insufficient infrastructure** for remote diagnosis and **telemedicine.**

THE HINDU

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Diversion of doctors continues as issue of shortage remains unresolved at govt. hospitals

Published - December 22, 2024 12:40 am IST - Chennai

THE HINDU BUREAU

PRINT

Diagnostics • 2 Min Read

Humble stethoscope can detect heart defects in children with 95% accuracy: Study

spital in Bengaluru on October 29 after hearing that actor Puneeth Rajkumar was admitted for a heart ailment.

Puneeth Rajkumar, 46, one of the marquee names of Kannada film industry and the youngest of the five children of matinee idol Dr. Rajkumar passed away on October 29 after suffering cardiac arrest in the morning. Revenue Minister R. Ashok announced the demise of the actor at Vikram Hospital, Bengaluru. Puneeth Rajkumar is survived by his wife Ashwini Revanth and two daughters Drithi and Vanditha.

Dr. Ranganath Naik of Vikram Hospital said, "Puneeth Rajkumar complained of chest pain in the morning and was rushed to the private clinic of his family physician where an ECG test was done. It showed a heart attack and he was immediately rushed to Vikram Hospital

Business Standard

Monday, January 06, 2025 | 11:53 PM IST EN | Hindi

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Home / India News / Delhi health minister highlights doctors shortage, slams L-G for inaction

Delhi health minister highlights doctors shortage, slams L-G for inaction

How EchoCare Addresses These Gaps

Affordable and Accessible:
Low-cost design makes advanced diagnostic tools available to rural healthcare professionals.
Targets regions where lack of specialist care leads to preventable deaths.

Telemedicine Support:
Facilitates remote consultations and diagnoses.
Improves healthcare access for remote and underserved areas.
Potential to address broader challenges, including maternal and child health.

No Expertise Required:
AI-driven analysis empowers non-experts to diagnose accurately and intervene early.
Reduces dependency on specialized training for healthcare workers.

Portable and Easy to Use:
Compact design enables use in diverse healthcare settings.
Suitable for at-home monitoring or mobile healthcare workers in rural areas.

Prevention through Early Detection:
AI-powered analysis identifies early signs of CVDs and respiratory diseases.
Prevents life-threatening events like heart attacks and heart failure.

Proof-of -Concept

Objective: Transforming **Diagnosis** in Underserved Healthcare

Problem : India faces 272 CVD deaths/100K population due to **limited diagnostic tools**, especially in rural regions.

Solution : **Affordable, AI-powered digital stethoscope** for real-time **heart,lung and abdomen** sound analysis, anomaly detection, and **telemedicine** support.

Resources: **Software**

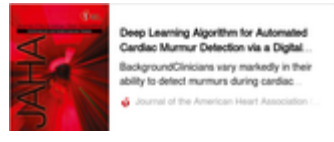
- AI/ML-powered diagnostics, data sets available
- Mobile app with real-time visualizations, confidence-based diagnostic suggestions, and secure telemedicine integration.
- Privacy-focused: Federated Learning ensures data security.

Hardware

- Microphone, Processing Unit: Embedded microcontroller (**ESP32**)
- **Raspberry Pi** can run lightweight AI models (like CNNs) locally, providing immediate results without requiring internet connectivity.**1 GB storage**
- Dual **connectivity** (Bluetooth + wired), Durable, medical-grade housing with an 8+ hour **battery life**.

Algorithm Performance (References from Research)

- **Deep Learning Algorithm for Cardiac Murmur Detection:**
  - Sensitivity: 76.3%, Specificity: 91.4% for murmurs (JAHA).
- **Low-Cost AI Model for CVDs and Respiratory Diseases:**
  - Accuracy: 99.94% using MFCC features and CNNs.



https://www.mdpi.com/1424-8220/22/11/4263,

Proof of Concept (Cont.)

https://sansad.in/getFile/loksabhaquestions/annex/1711/AU1553.pdf?source=pqals

Market Validation

- **Primary Market:**
  - 24,935 (2022) Primary Healthcare Centers
  - Telemedicine Market Growth: According to analysts, Grand View Research, "The global telemedicine market size was valued at USD 114.98 billion in 2023 and is expected to grow at a compound annual growth rate (CAGR) of 17.96% from 2024 to 2030", signifying an untapped market. The increasing demand for teleconsultation, telepathology, teleradiology and e-pharmacy have acted as the levers for this growth, the report says.
  - .
- **Secondary Market:**
  - Home users: Growing demand for chronic disease monitoring.
  - NGOs and government health programs for rural outreach (e.g., Ayushman Bharat).
- **Scalability:** Customizable AI models for diverse use cases like maternal and child health, ambulance services, and remote clinics.

Competitive Advantages

- **Affordability:** Under ₹15,000 price point—40–60% cheaper than competitors (Littmann: ₹25,000+, Eko Core: ₹38,000).
- **Accessibility:** Designed for non-specialists; works offline in low-connectivity areas.
- **Comprehensive Diagnostics:** Real-time insights with AI-backed confidence scores.
- **Privacy-Centric:** Federated Learning to protect patient data while improving models.

Project Team & Advisors

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Auscultation Study,

Devashish Tripathi
4th Year, DSE
Software

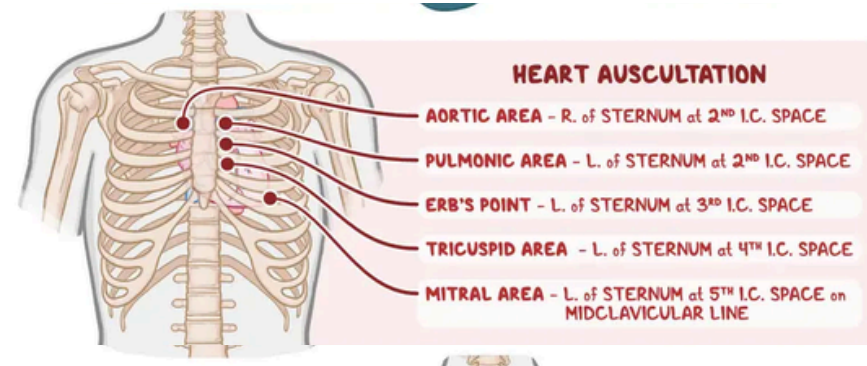
Haroon R Lone
EECS
Faculty Advisor

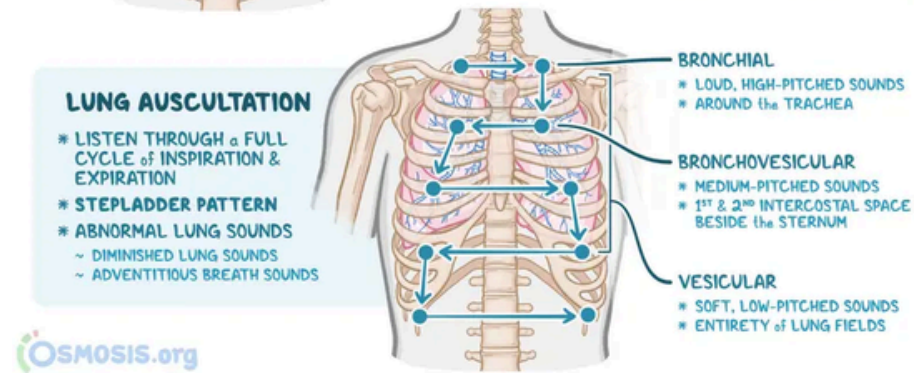
Scope of Auscultation

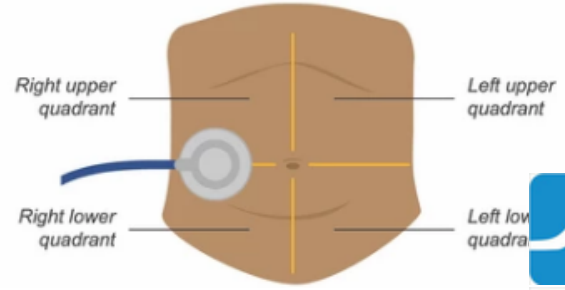
- Cost Saving and Reliable method of diagnosis

- **Heart**
  - **Leakage in Valves causes Murmur due to turbulence**
- **Lung**
  - **Listening for cackle, wheezes, rough grating sounds**
- **Abdominal**
  - **Murmurs, Bowel Sounds, and unusual Rubs**

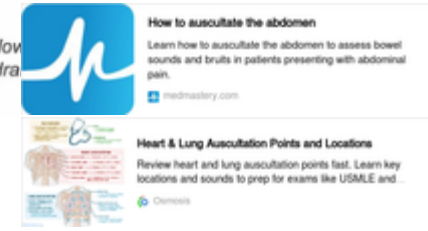
- Electrocardiogram (ECG) difficulty in detecting structural abnormalities in heart valves and defects characterized by heart murmurs.
- Echocardiogram (echo) provides information size, shape, structure and function of the heart. MRI produces both still and moving pictures of the heart and major blood vessels. CT uses uses x-rays to create detailed pictures of the heart and its blood vessels.
- Major disadvantages of echo, MRI and CT are their high cost and theneed of specialized personnel to operate the complex machines







Leng et al. BioMed Eng OnLine (2015)



Novelty

https://www.sciencedirect.com/science/article/abs/pii/0141542583900985

https://wikidoc.org/index.php/Peritonitis_physical_examination

- Designed to Save Lives

Lungs

Pneumonia	Asthma	Bronchitis	TB
COPD	edema	Pleural effusion	

Heart

Heart murmurs	Arrhythmias	heart attacks
Heart valve		heart failure

Abdomen

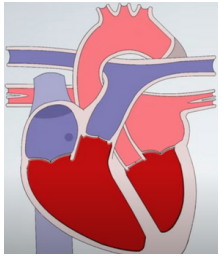
Bowel sounds	aneurysm	Liver enlargement
Peritonitis		Bowel obstruction

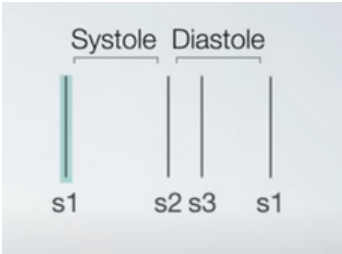
Vascular	Other
Peripheral artery disease	heart defects (in children)
narrowed arteries	Pregnancy-related issues

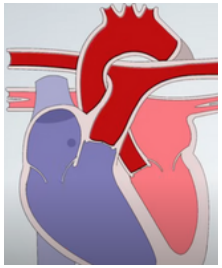
Heart Sounds

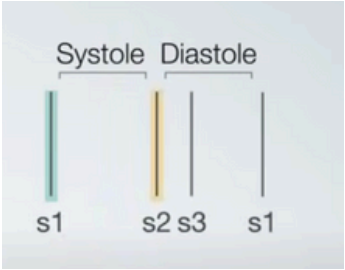
- Biomechanics of Heart Ascultation

- **S1 and S2**

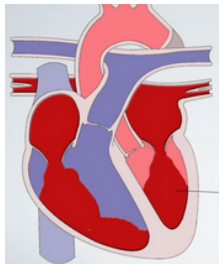


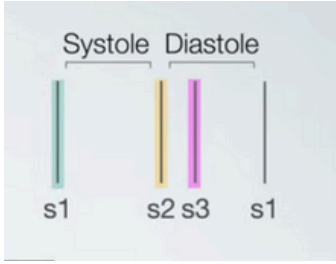




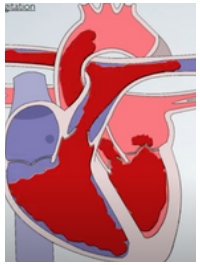


- **S3** abnormal in adults

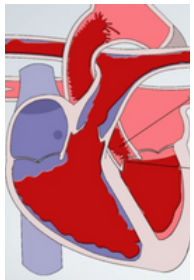


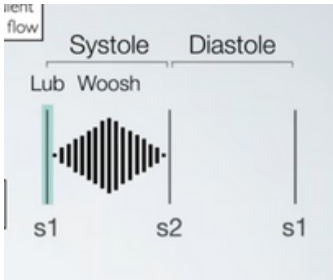


- **Mitral Regurgitation**

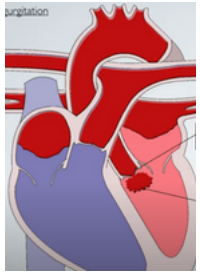


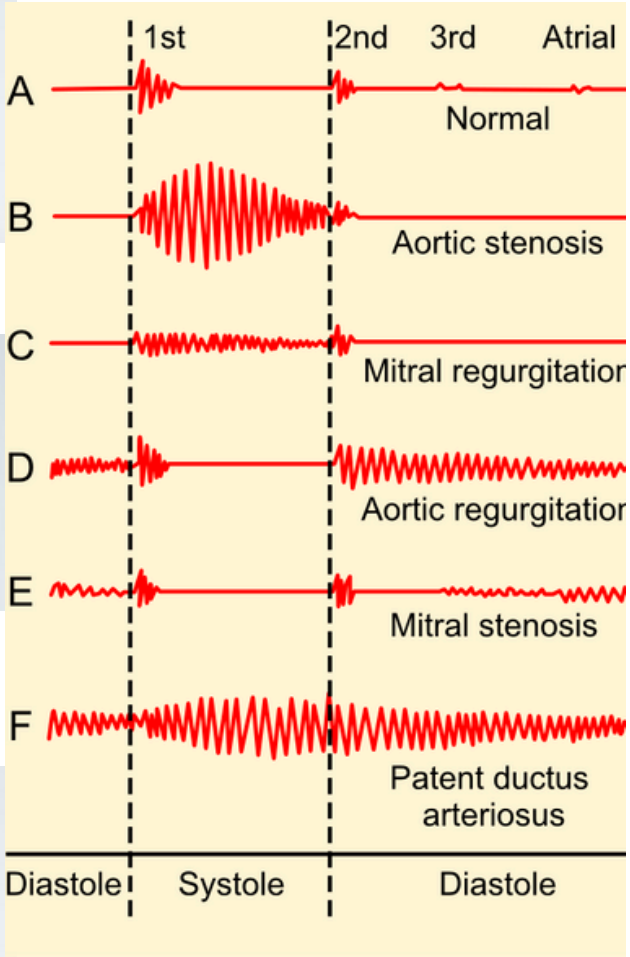
- **Aeortic Stenosis**





- **Aortic Regurgitation**



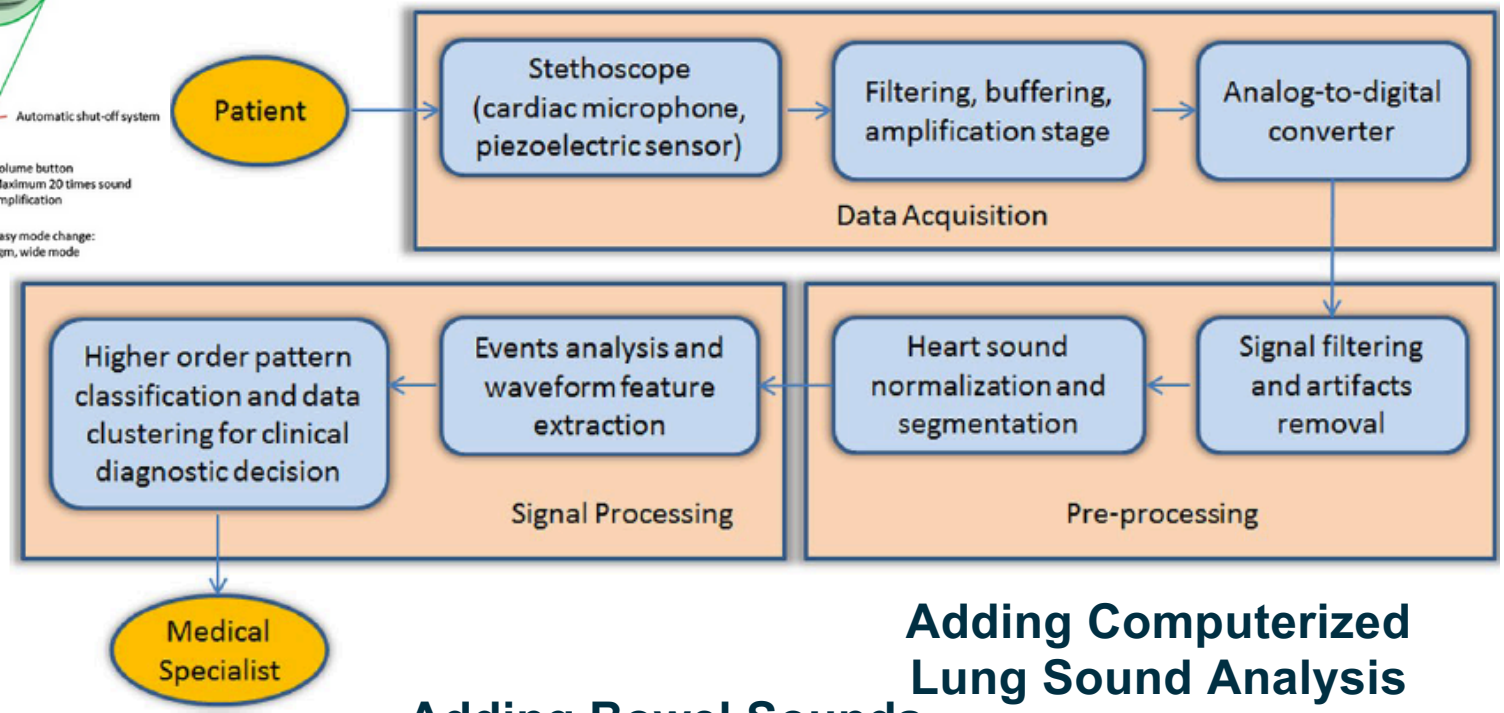


Denoising + Amplification

- Eliminating ambient noise through feature recognition

Adding Privacy-Preserving ML

Including Various Denoising Techniques



Adding Computerized Lung Sound Analysis

Adding Bowel Sounds Computerised Analysis

Leng et al. BioMed Eng OnLine

Novelty

Designed to be Accessible

Data Secure

Uses to process patient data locally while improving AI model accuracy globally using privacy preserving ML

Portable

Lightweight, Compact, Intuitive Operation, Deployable in remote Areas

Easy To Use

non-specialists, with app-based guidance and minimal training needs, making it suitable for ASHA workers, caregivers, and individuals at home

Diagnostics

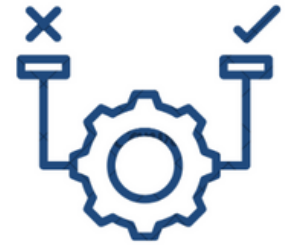
CNN Algorithms for heart/lung sound classification and anomaly detection.

Connectivity

Data Sharing functionality to get an expert opinion

Feasibility

- Optimally integrating Existing Paradigms



Hardware

- **Industry-Grade Microphone** with Noise Cancellation.BY-M1 microphone
- **Bluetooth connectivity** for wireless operation
- **Wired functionality** for areas where mobile networks are unreliable.
- High-capacity **rechargeable battery**, offering 8+ hours of continuous usage .
- **Processing Unit:** (ESP32)
- **Raspberry Pi** for computation
- 1 GB onboard storage for temporary sound data buffering in low-network areas.
- **Medical-Grade Housing**, durable and easy to use in various healthcare settings.

Model Development

- **Preprocessing**: Audio signals are processed as waveforms, which can be Fourier Transformed to extract the specific spectral plots. Libraries like librosa and torchaudio will be used for this step.
- **Feature Extraction:** LSTMs will be used to analyse temporal patterns, while CNNs will be used to analyse spectrograms and waveforms.
- **CNN Classification:** CNNs analysing the spectrograms will also be used to classify the sounds into various categories (regular/irregular, normal/abnormal, etc.).
- **SVM Classification:** Features extracted from LSTMs, CNNs and other relevant information will be used to train the classification model to identify irregularities and provide a confidence score for a preliminary diagnosis.

FEASIBILITY

- While ensuring safety and reliability

Key Ideas

- **Anomaly Detection:** Taking into account factors like age and gender, the model would learn from feature-rich representations. Thus, it will be able to flag anomalies in a robust fashion.
- **Dataset:** Initially, existing datasets like Heartwave and those sourced from Kaggle[1, 2] will be used. As the project advances, we will use our own database in a Federated Learning manner.
- **Federated Learning:** Allows training from patient data without privacy concerns, as the method first trains on local devices, which are then used to provide updates for a global server.

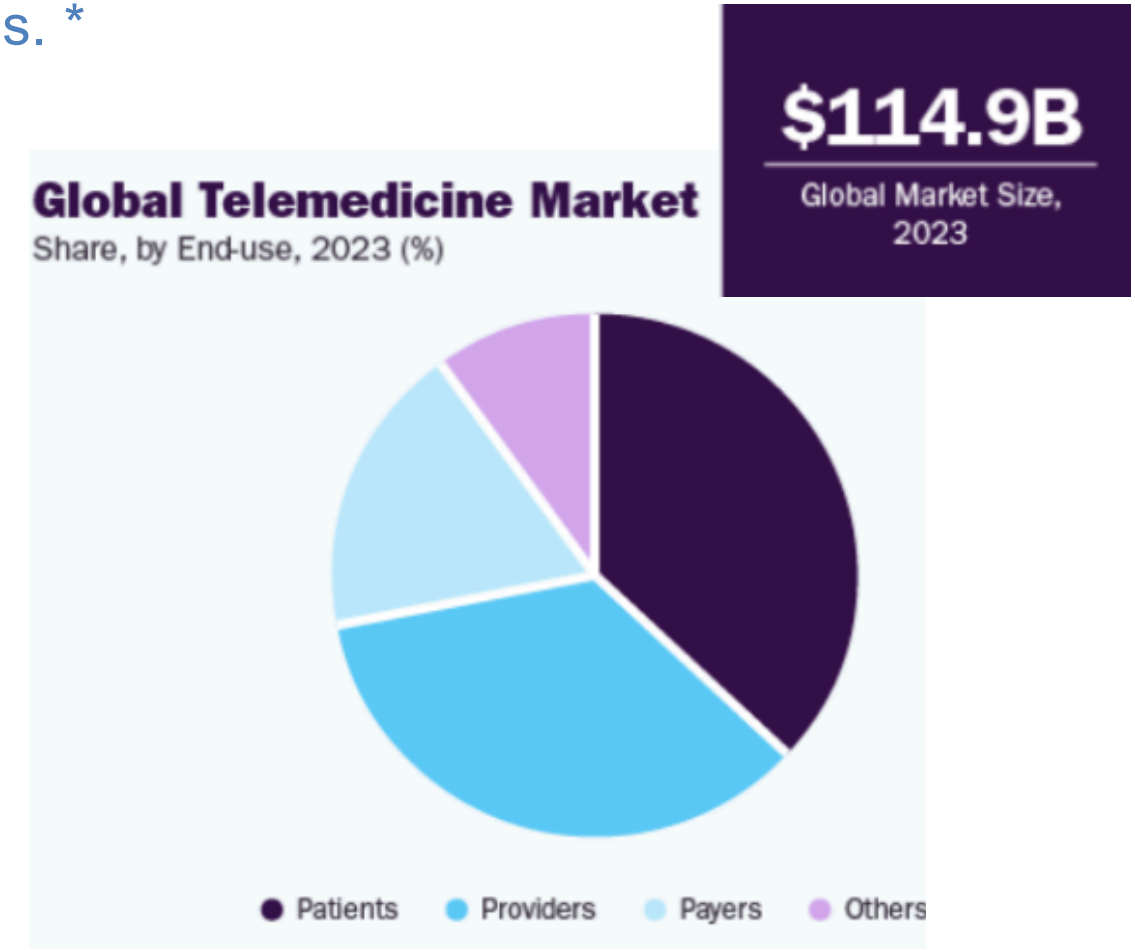
User Interface

- **Mobile app Interface**
- **Real-Time Visualization**: The app will display real-time visualizations of heart and lung sounds, with both audio waveforms and spectrograms for the healthcare professional to view.
- **Diagnostic Suggestions:** The app will offer confidence scores for various potential diagnoses based on the AI's analysis of the sounds.
- **Reports**: Simple language reports will be generated, presenting clear diagnostic conclusions and actionable insights for healthcare professionals.

MARKET ANALYSIS

- India's estimated mid-year population in July 2021 was 1.36 billion – around 895 million in rural areas and more than 472 million in urban areas. *

- Grand View Research, "The **global telemedicine market** size was valued at USD 114.98 billion in 2023 and is expected to grow at a compound **annual growth rate (CAGR) of 17.96%** from 2024 to 2030", signifying an untapped market. The increasing **demand for teleconsultation, telepathology, teleradiology and e-pharmacy** have acted as the levers for this growth, the report says.



*https://ruralindiaonline.org/hi/library/resource/rural-health-statistics-2020-21/

COMPETIVE LANDSACPE

- Existing products are expensive and the product focus is on Medical Physicians as opposed to usage by Health workers, Volunteers and Individuals.

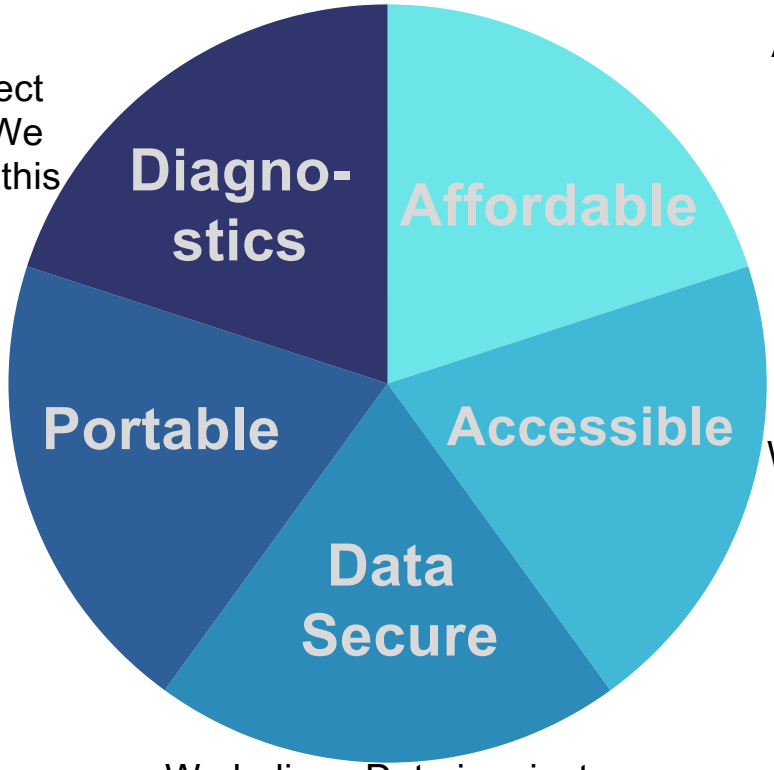
	Global		Indian
	3M Littmann Digital Stethoscope	**Eko Core Digital Stethoscope**	**AISteth**
Price	~₹30,000+ $379	~₹38,000 $469	₹ 18000
Features	High audio quality but no AI integration	Limited AI for cardiac analysis, professional-focused	AI/ML integration for heart and lung sound detection. Bluetooth connectivity with app for visual augmentation and data sharing.
Limitations	Requires medical expertise; not suitable for home use or rural healthcare.	High cost, no significant focus on rural deployment or home-based care. healthcare.	Primarily focused on urban healthcare providers and telemedicine, with limited rural deployment strategies. Primarily professional use, lacks specialized features for home users or rural healthcare workers.

Value Proposition

- Patient Well-being is the priority for us. EchoCare's diagnostics should be one of the reasons that healthcare workers are able to save lives.

A wide variety of ailments can be discovered by a stethoscope. A correct diagnosis can mean life and death. We ensure using multiple algorithms that this is done

A powerhouse for Rural Healthcare workers operating on a shoestring budget to help them allocate resources more efficiently



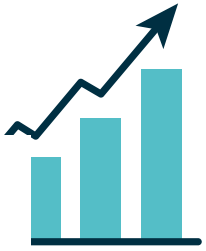
People who are in remote areas do not have access to state of the art instruments. Furthermore in disaster situations, these tools are invaluable

With a user friendly interface and step by step direction, Any Healthworker would be easily able to use it without the need of extensive training by NGOs/other organisations

We believe Data is private right especially for those in vulnerable state. Using Federated Learning, we will ensure that Data privacy

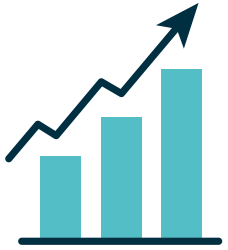
Project Timeline for 6 months

- We aim to develop a fully working prototype at the end of 6-months so that the first tests can be carried out.



1. Finalize project plan, AI model design, and hardware integration
2. First AI model ready; Initial lab testing begins; Improvements and work on other models
3. Refine AI model and software; First field testing
4. Analyze field data; Start studied into compliance with regulations
5. Development of Mobile Application, Data Sharing and Design of User Interface
6. Deploy in 5+ rural centers; Collect feedback for optimization; finalization of first protoype

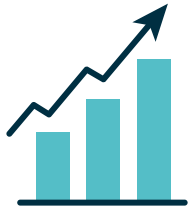
Scaling



- Before deployment we will ensure complete safety and accuracy of EchoCare. This involves subsidizing the first models and use the feedback to improve on the product

Year 1, Q1	Design and development of the AI model for diagnostic accuracy as well as Develop the first working prototype
Year 1, Q2	Begin real-world field testing at selected rural healthcare centers and telemedicine platforms.
Year 2, Q1	Begin real-world field testing at selected rural healthcare centers and telemedicine platforms and ensure complaince
Year 2, Q2	Begin pilot deployment in 10+ rural healthcare centers, focusing on usability and performance in real-world settings.
Year 3, Q1	Achieve 1000+ active users and gather performance feedback for further improvements.
Year 3, Q2	

Business Model



- We plan onto Target both governmental and Non-Governmental healthcare organizations. Furthermore down the line we also plan onto target mainstream healthcare professionals. Health enthusiasts will also have accessibility to our products

- We will have also have a rental system where our products can be leased for some amount of time alongside a conventional upfront payment.

- We will also target a growing healthcare enthusiast community who are heavily invested in improving their lifestyle.

Conclusion

By investing in EchoCare, you are not just funding a medical device; you are enabling a revolution in accessible healthcare diagnostics.

Massive Market Potential	EchoCare addresses the pressing global need for accessible, affordable, and reliable diagnostic tools, especially in underserved rural and remote healthcare settings.
Technological Edge	Combines cutting-edge AI/ML algorithms with robust hardware, ensuring real-time, accurate diagnostics for heart and lung conditions.
Scalable and Privacy-Centric	Leveraging federated learning ensures patient data privacy while continuously improving model accuracy, setting a benchmark for ethical AI use in healthcare.
Affordability and Portability	Designed to be cost-effective and portable, EchoCare democratizes access to advanced diagnostic tools, unlocking opportunities in telemedicine and emergency care.
Social Impact	Directly contributes to reducing diagnostic delays, improving patient outcomes, and empowering healthcare professionals in resource-limited environments.
Proven Feasibility	Backed by a clear roadmap for hardware development, AI implementation, and real-world testing, EchoCare is well-positioned for rapid prototyping and market entry.
High ROI Potential	By investing in EchoCare, you are not just funding a medical device; you are enabling a revolution in accessible healthcare diagnostics.

Sno.	Part	Number	Amount
1	RPI5-8GB-SINGLE	2	16526
2	ESP32	1	382
3	Microphones (RMIC-110-5-3015-NS1)	10	1140
4	INA114 (instrumentation Amp)	5	1275
5	ADALP2000 (Analog Kit)	1	9134
6	Glia Open Source Stethoscope	2	5000
7	Stationary	1	300
8	Other Consumables (plastic kit,swabs, cleaners, sanitiser)	4	5000
9	Rechargeable battery (2500 maH)	4	924
10	connecting wires	40(M-M) 40(M-F) 40(F-F)	200
11	Mobile App Development		50000
12	Start-Up Registration Fee		25000
13	IP Filing Fee		20000
14	Misc Expenses		30000
11	3D printed parts, computer system		35116
	Total		200000/-