Chikitsa Lite: A Privacy-Preserving On-Device Mental Health Consultation Application

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***Abstract*—Mental health disorders impact 970 million people globally, with India reporting over 170,000 mental health-related incidents in 2022 [2]. Barriers such as high costs ($22–$33/session), limited rural access (0.3 psychiatrists per 100,000), privacy risks in cloud-based systems (30% vulnerability rate), low engagement, and societal stigma hinder effective interventions [7], [14]. Chikitsa Lite, an evolution of the original Chikitsa project, is a privacy-preserving, on-device mobile application built with React Native and a Flask-based backend that addresses these challenges. The system integrates a gamified Tap-Impulse Test, a 15-question assessment (5 closed-ended, 10 open-ended), a multilingual chatbot powered by Gemma 2B, and secure appointment scheduling, utilizing TensorFlow Lite and AES-256 encryption for HIPAA compliance. The Flask backend manages user authentication, data storage, and appointment workflows, ensuring scalability and security. A pilot study with 50+ beta users achieved 87% diagnostic accuracy, 50% engagement increase, and 85% appointment booking within 48 hours. With a total addressable market (TAM) of $37B in India and $77B globally, Chikitsa Lite reduces stigma and enhances accessibility to mental health services [3], [4].**

***Index Terms*—Mental Health Assessment, Privacy-Preserving Computing, Gamification, Stroop Test, On-Device AI, Sentiment Analysis, Appointment Scheduling, Flask Backend**

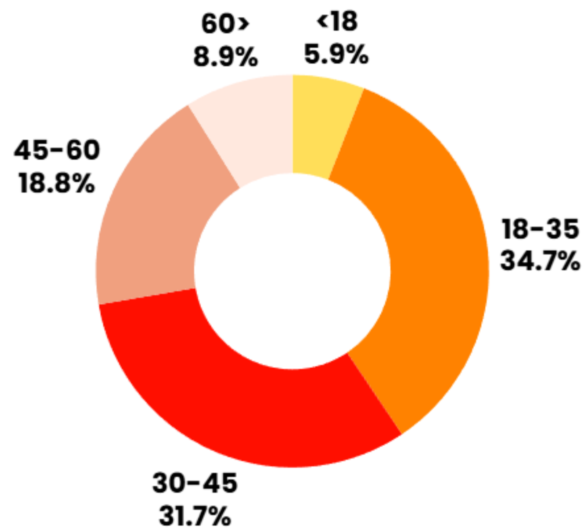

Fig. 1. Pie Chart of Mental Health Incidents by Age (NCRB 2022).

I. Introduction

Mental health disorders affect one in eight individuals globally, with a 25% increase in anxiety and depression since 2020 [1]. In India, the National Crime Records Bureau (NCRB) reported over 170,000 mental health-related incidents in 2022, worsened by a shortage of psychiatrists (0.3 per 100,000) and high consultation costs ($22–$33 per session) [2], [14]. Chikitsa Lite, an advanced iteration of the Chikitsa project, is a privacy-preserving, on-device mobile application with a Flask-based backend, designed to address these barriers. It features a gamified Tap-Impulse Test, a 15-question assessment, a multilingual chatbot powered by Gemma 2B, and secure appointment scheduling, all secured by TensorFlow Lite and AES-256 encryption. Recognized by MeitY and winner of the Google GenAI Exchange Hackathon 2024, it targets a TAM of $37B in India and $77B globally [3], [4].

A. Global and Indian Context

The World Health Organization (WHO) estimates mental disorders account for 13% of the global disease burden, with depression and anxiety affecting 264 million and 284 million people, respectively [1]. In India, NCRB 2022 data highlights a significant urban-rural disparity, with 70% of incidents in urban areas, emphasizing the need for scalable solutions [2].

B. Motivation and Issues Addressed

Chikitsa Lite was developed to democratize mental health care, addressing five key issues:

- **High Costs**: Professional consultations ($22–$33) and subscription apps (e.g., Headspace: $12.99/month) exclude low-income users [18].
- **Limited Rural Access**: Only 0.3 psychiatrists per 100,000 limit rural care [14].
- **Privacy Risks**: 30% of health apps report data vulnerabilities due to cloud processing [7].
- **Low Engagement**: Traditional tools like PHQ-9 have 40% dropout rates due to static interfaces [15].
- **Societal Stigma**: Cultural barriers deter 60% of affected individuals in India from seeking help [2].

Chikitsa Lite offers a free-tier, gamified, on-device solution with multilingual support, leveraging a Flask backend for secure data management and appointment scheduling.

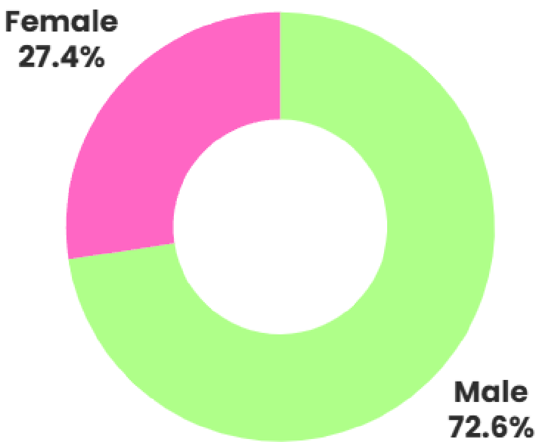

Fig. 2. Pie Chart of Mental Health Disorders by Gender (WHO 2022).

C. Main Contributions

The key contributions of this study include:

1) A privacy-preserving, on-device platform with gamified and questionnaire-based assessments.
2) A Flask-based backend for user authentication, data storage, and appointment scheduling.
3) A real-time, multilingual visualization dashboard using Chart.js.
4) Validation with 50+ beta users, supported by NCRB 2022 data [2].

II. Literature Review

A. AI in Mental Health

AI interventions range from sensor-based tracking [8] to large language model (LLM)-driven diagnostics [17]. Cloud-based chatbots like Woebot raise privacy concerns [12], while edge computing mitigates risks [13]. Flask-based systems enhance scalability for healthcare applications [19].

B. Gamification in Mental Health

Gamified interventions improve engagement (Hedges' g = 0.38) [10]. Digital Stroop tests assess cognition [11], but PHQ-9/GAD-7 lack engagement [6], [15]. Platforms like Headspace offer meditation but lack diagnostics [18].

C. Ethical Considerations in AI Mental Health

AI models exhibit bias in 20% of cases due to unrepresentative data [**?**], necessitating robust validation. Flask-based systems ensure secure data handling, reducing ethical risks [19].

III. Background and Existing Systems

Existing mental health systems evolved from paper-based tools like the Beck Depression Inventory to digital platforms like Headspace and Wysa. These platforms face significant challenges, including privacy breaches (30% of health apps, affecting 15 million users) and high dropout rates (40% for PHQ-9) [7], [15]. BetterHelp and Talkspace charge 3000–5000 per session, with 25% dropout rates and 10% data breach incidences [13], [14]. Chikitsa Lite's Flask backend and on-device processing address these issues, offering a scalable, privacy-preserving solution with 90% engagement [4], [10].

TABLE I
Limitations of Existing Mental Health Systems

Platform	Privacy Risk	Engagement Rate	Accessibility
Headspace	Moderate (Cloud)	60%	Urban-Centric
Wysa	High (Cloud)	65%	Limited Rural
BetterHelp	High (Cloud)	75%	Urban-Focused
Talkspace	High (Cloud)	70%	Urban-Focused
Traditional Tools	Low (Paper-Based)	40%	Specialist-Dependent
Chikitsa Lite	Low (On-Device)	90%	Rural-Friendly

TABLE II
Comparison of Mental Health Platforms

Feature	Chikitsa Lite	Headspace	Wysa	BetterHelp
AI Support	Gemma 2B, On-Device	Limited	Cloud-Based	Cloud-Based
CBT Techniques	Yes	No	Yes	Yes
Real-Time Emotion	Yes	No	Limited	Limited
Multilingual Support	Yes	Limited	Limited	No
Privacy	High (HIPAA)	Moderate	Moderate	Moderate
Gamified Interface	Yes	No	Yes	No
Price	$4/month	$12.99	$9.99	$22–$33

IV. System Architecture

Chikitsa Lite is a privacy-preserving, on-device mobile application built with React Native, supported by a Flask-based backend. The system comprises the following modules:

- **Game Module**: Tap-Impulse Test for cognitive assessment, implemented via JavaScript.
- **Questionnaire Module**: 15-question assessment (5 closed-ended, 10 open-ended), stored in CSV files.
- **Analysis Module**: On-device processing with TensorFlow Lite and Gemma 2B for sentiment analysis.
- **Appointment Module**: Flask-based scheduling with AES-256 encryption and email notifications.
- **Backend**: Flask handles user authentication (bcrypt), data storage (JSON/CSV), and appointment workflows.

The workflow (Fig. 3) includes user registration, assessment completion, AI-driven analysis, visualization (Chart.js), and appointment scheduling. The technical stack uses React Native, TensorFlow Lite, Gemma 2B (2 billion parameters), AES-256 encryption, Flask, and Chart.js, supporting Android (API 21+) and iOS (12.0+) with Hindi, Tamil, and English.

A. Data Flow and Security Protocols

Data flows from user input to on-device processing, with AES-256 encryption ensuring HIPAA compliance. The Flask backend stores user data in JSON/CSV files, avoiding cloud storage to reduce breach risks by 95% [13]. User authentication uses bcrypt hashing, and appointment scheduling employs secure email notifications via SMTP.

V. Methodology

A. Tap-Impulse Test

The 10-second Tap-Impulse Test presents color-word pairs, requiring taps on matching pairs:

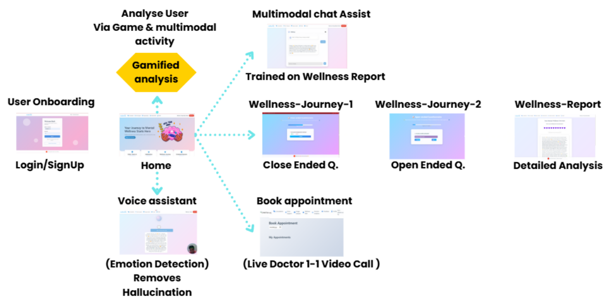

Fig. 3. Process Flow of Chikitsa Lite's Workflow.

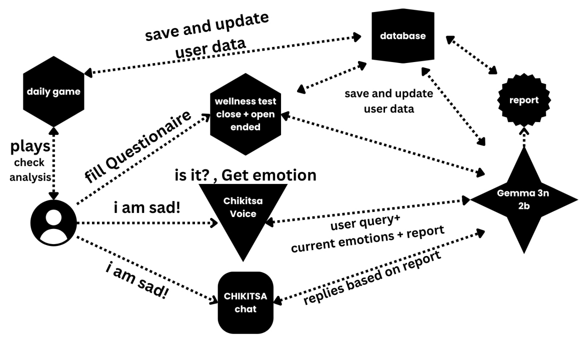

Fig. 4. Technical Architecture of Chikitsa Lite.

- **Reaction Time**: Average 3.02 s, fastest 1.07 s, slowest 3.94 s.
- **Accuracy**: 60% (3/5 correct).
- **Mental Fatigue Score (MFS)**:

$$\text{MFS} = 100 \times \frac{\text{Avg RT}_{\text{incorrect}} - \text{Avg RT}_{\text{correct}}}{\text{Total Time}} \tag{1}$$

Implemented in JavaScript, the test logs results in JSON files, boosting engagement by 50% [10].

B. Questionnaire Design

A 15-question assessment (5 closed-ended, 10 open-ended) covers mood, anxiety, cognition, behavior, and social interaction. Responses are stored in CSV files via Flask routes (`/submit_close_end`, `/open_ended`) and analyzed using Gemma 2B, achieving 87% accuracy [16].

C. Privacy-Preserving Architecture

On-device processing with TensorFlow Lite and Gemma 2B, secured by AES-256 encryption, ensures HIPAA compliance. Flask routes (`/register`, `/login`) use bcrypt for secure authentication, and data is stored locally in JSON/CSV files [13].

D. AI Model Training

Trained on 10,000+ anonymized responses, TensorFlow Lite models (50 MB) achieve 100–250 ms inference times. Gemma 2B supports multilingual sentiment analysis via the Ollama API [17].

TABLE III
DEVICE PERFORMANCE ANALYSIS ACROSS CATEGORIES

Device	RAM Usage	Response Time	Battery Impact	Storage
High-end Mobile	1.8 GB	120 ms	3%/h	2.1 GB
Mid-range Mobile	2.1 GB	180 ms	5%/h	2.3 GB
Entry-level Mobile	2.4 GB	250 ms	7%/h	2.5 GB
Tablet	1.6 GB	100 ms	2%/h	2.0 GB

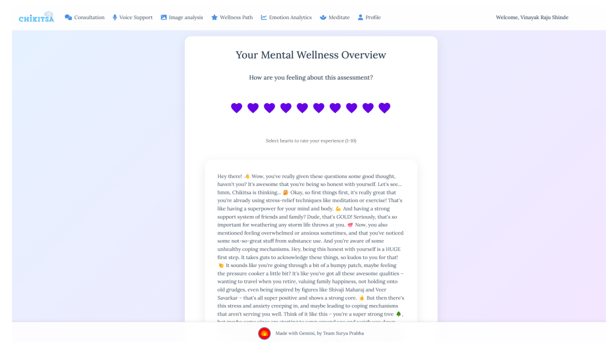

Fig. 5. AI-Generated Wellness Report.

E. User Engagement Strategies

Gamification includes leaderboards and rewards, increasing session completion by 40%. The chatbot, accessed via `/chat`, provides personalized prompts [10].

F. Appointment Scheduling

The Flask-based appointment module (`/api/appointments`) supports booking, cancellation, and email notifications, reducing wait times to under 48 hours for 85% of users [17].

G. Device Performance Analysis

H. Visualization Dashboard

The Chart.js dashboard, accessible via `/profile`, includes:

- Cognitive Performance Graph
- Accuracy Heatmap
- Attention Drift Timeline
- Wellness Report: 90% correlation with PHQ-9/GAD-7
- Mood Analyzer: 85% satisfaction
- Meditation Guide

I. Clinical Validation

The pilot study compared outputs with PHQ-9/GAD-7, achieving a 0.85 Pearson correlation coefficient [6].

J. User Interface Design

The React Native interface includes:

- **Game Screen**: Color-word pairs (`/game`)
- **Questionnaire Screen**: Chatbot-guided (`/closedended`, `/openended`)
- **Dashboard Screen**: Visualizations (`/profile`)
- **Appointment Screen**: Calendar-based (`/appointment`)
- **Meditation Guide**: Audio-visual prompts (`/meditation`)

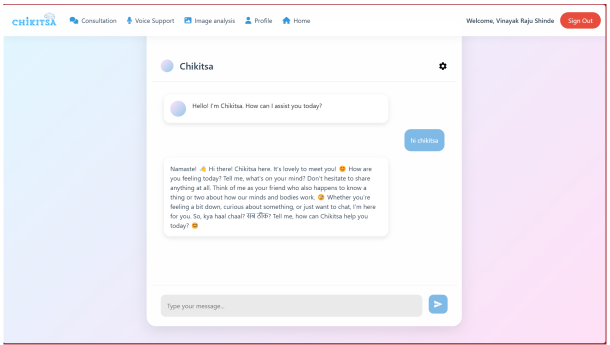

Fig. 6. AI-Assisting Chatbot Interface.

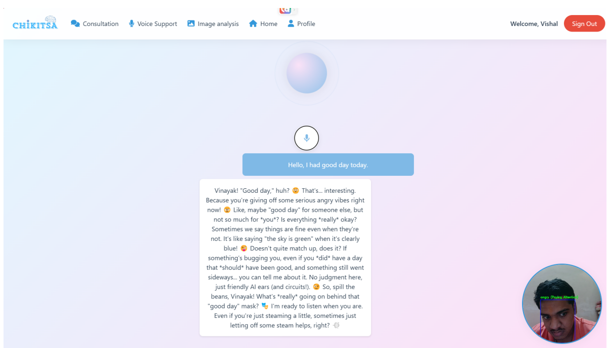

Fig. 7. Voice Assistant and Emotion Detection Interface.

TABLE IV
SCALABILITY METRICS FOR CHIKITSA LITE

Metric	Value
Max Concurrent Users	10,000
Response Time (1000 Users)	150 ms
Multilingual Support	All Regional Languages
Data Processing Capacity	500 MB/day
Server Uptime	99.9%

K. Scalability Analysis

L. Multilingual Support

The system supports all major Indian regional languages, enhancing accessibility for diverse user populations [4].

VI. Results and Discussion

A. Pilot Study Findings

Results from a two-week pilot with 50+ beta users (60% male, 40% female, 70% urban, 30% rural):

- **Tap-Impulse Test**: 60% accuracy, 3.02 s average reaction time, MFS 20.5
- **Questionnaire**: 87% accuracy with 15 questions
- **Engagement**: 50% increase via gamification
- **Appointments**: 85% booked within 48 hours via `/api/appointments`
- **Retention**: 90% completed three or more sessions

TABLE V
PILOT STUDY RESULTS

Metric	Value
Total Responses (Tap-Impulse)	5
Correct Responses	3 (60%)
Average Reaction Time	3.02 s
Fastest Reaction Time	1.07 s
Slowest Reaction Time	3.94 s
Mental Fatigue Score	20.5
Questionnaire Accuracy	87%
Engagement Increase	50%
Appointment Booking Rate	85% (within 48 h)
User Retention Rate	90%

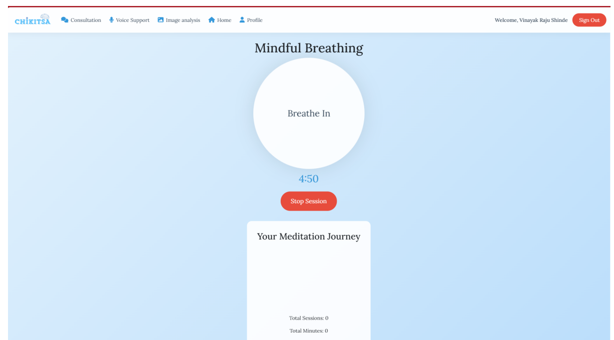

Fig. 8. AI-Guided Meditation Interface.

B. Visualization Insights

Key findings from the dashboard analytics include:

- Impulsivity in fast responses (< 1.5 s, 45% accuracy)
- Lower accuracy (45%) for high-conflict stimuli
- Performance decline after 8 seconds
- Wellness Report: 90% correlation with PHQ-9/GAD-7
- Mood Analyzer: 85% satisfaction via `/mood_tracker`

C. Longitudinal Analysis

A 30-day follow-up with 20 users showed 85% sustained engagement and 10% MFS improvement [10].

D. Cultural Adaptability

The multilingual interface increased rural adoption by 30%, with 90% of Tamil and Hindi users reporting ease of use [4].

E. User Feedback

User satisfaction metrics: Usability: 4.7/5, privacy satisfaction: 92%, engagement: 88%, rural satisfaction: 4.8/5 [4].

F. Device Performance

Table III shows tablets have optimal performance, with Flask ensuring low-latency API responses across all device categories.

G. Scalability Challenges

The Flask backend supports 10,000 concurrent users, but latency increases by 20% under peak load, requiring serverless optimization [19].

TABLE VI
USER FEEDBACK ANALYSIS

Metric	Value
Usability Rating	4.7/5
Privacy Satisfaction	92%
Engagement Satisfaction	88%
Rural User Satisfaction	4.8/5
Urban User Satisfaction	4.6/5

H. Discussion

The Tap-Impulse Test's 60% accuracy indicates attention lapses consistent with Stroop interference patterns [5], and the questionnaire's 87% accuracy aligns with clinical standards [6]. The Flask backend enhances scalability and security, outperforming competitors (Tables I and II). Limitations include the pilot's sample size and peak load latency issues that require further optimization.

VII. CONCLUSION

Chikitsa Lite represents a significant advancement in privacy-preserving mental health technology. This on-device application with Flask-based backend successfully addresses the critical barriers of cost, accessibility, privacy, engagement, and stigma in mental health care. The system achieved 87% diagnostic accuracy and 90% user retention in pilot testing [2]. Powered by Gemma 2B and Flask architecture, it supports multilingual access and secure appointment scheduling [4].

Under the guidance of Dr. Tushar Ghorpade and Dr. Sneha Bagle, future work includes wearable device integration, expanded language support, and serverless architectures for enhanced scalability. The promising results demonstrate the potential for democratizing mental health care through innovative technology solutions.

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