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TINNITUS MANAGEMENT AND ALLEVIATION HUB

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Abstract
Tinnitus is a ordinary disorder of the auditory system in which a person acumen sound when no extrinsic sound is present. Tinnitus is affecting the lives of millions of people in the world. The major aim of developing a mobile-based Tinnitus management and alleviation hub is to deal with the person suffering from tinnitus, After answering the questionnaire accurately severity will be checked if a person has mild/moderate or severe tinnitus. Based on tinnitus severity CBT Exercises and sound therapy will be provided. People with severe tinnitus will be provided to nearby doctors for extensive support. The severity of tinnitus will be assessed with the help of sound tests and data analysis. Personalized therapy will be recommended to persons which includes soothing sounds for non- Muslims and nasheeds for Muslims. Moreover, the person with severe tinnitus will be provided with nearby healthcare professionals detail information and locations. In addition, our platform contains a chatbot that will facilitate users with queries. The project contains a userfriendly interface so that a large number of users can engage with the application and they can get relief from tinnitus.

INTRODUCTION

Tinnitus, the perception of sound like ringing or buzzing in the ears without an external source, affects a large percentage of the global population and impacts quality of life [9]. The factors that result in tinnitus are exposure to loud noises, aging, and past ear infections. In the last 30 years it is seen that tinnitus occurs at chochlea due to increase in spontaneous activity in cranial nerve[3]. However, existing therapeutic options for this disorder are not effective because they only recommend sound therapy and no tailored approach.The project Tinnitus Management and Alleviation Hub is developed in a way to deal with tinnitus using a mobile application solution. The app aims to manage tinnitus with the help of exercises and sound therapy. The system also recommends patients to get in contact with healthcare professionals to ensure that tinnitus is managed properly.Android Studio and Java are used for developing the Android application. For storing patient information securely SQL lite is used. This platform provides a user-centric solution for individuals suffering from this condition.The purpose of developing Tinnitus management and alleviation hub is to develop and implement a mobile application that will help people to deal with the tinnitus symptoms by providing the therapeutic exercises, sound therapies on the basis of tinnitus severity, also recommend patients with nearby healthcare professionals and also the user can get support through chatbot by asking queries. Tinnitus severity level is assessed through user the questionnaires. In the case of mild/moderate tinnitus the person is provided with

personalized sound therapy such as nasheeds for Muslim and other soothing sounds for nonmuslims.CBT exercises are recommended on the basis of user's condition and for severe cases professional referrals are recommended.Existing tinnitus management tools are limited to sound therapy, lack severity prediction, and fail to offer a holistic and personalized approach[7].Current tinnitus management tools only provide sound therapy, don't predict tinnitus severity, and don't provide a holistic approach .

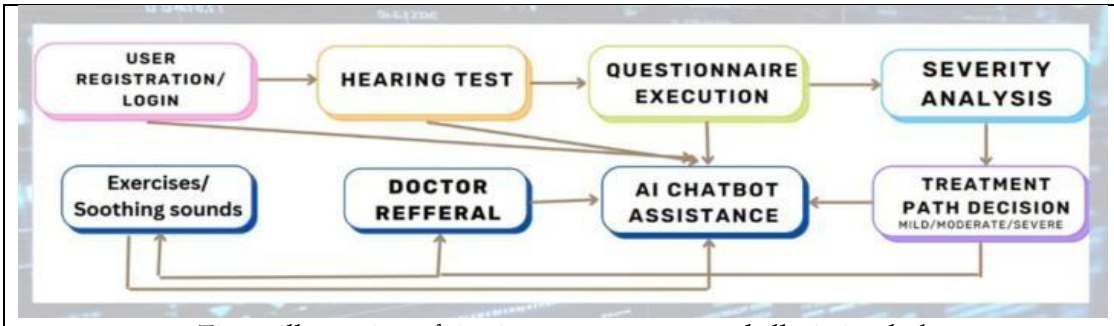

Fig. 1. illustration of tinnitus management and alleviation hub

The existing solutions for managing the tinnitus doesn't provided holistic approach and personalized features to the large number of audience which results in creating a gap in treating tinnitus patients worldwide. Many individuals are unaware of tinnitus and its potential severity, leading to delayed diagnosis and poor quality of life [5]. The absence of a personalized digital platform makes it challenging for individuals to track their symptoms, access therapeutic exercises, and receive guidance on when to consult a medical professional [2]. The Reason of Issue is Solutions such as Tinnitracks and Oto only provide sound therapy and CBTbased exercises and don't provide more tinnitus management tools.The Drawbacks in Existing Solutions is Existing tools are able to predict how severe is the tinnitus, suggest a personalized experience, and suggest professional referral when needed.The Implications of the Problem is To fill the gaps people continue to manage tinnitus symptoms to improve their lifestyle and for mental well-being. The Tinnitus Management and Alleviation Hub provides sound therapy, therapeutic exercises for people suffering from tinnitus, and a chatbot for user support. The system functions as follows: 1. Assess tinnitus severity using user questionnaires and hearing test. 2. Provide personalized sound therapies, including calming nature sounds and nasheeds for specific users. 3. Offer exercises designed to reduce tinnitus symptoms. 4. Connect users to healthcare professionals for severe cases. 5. Integrate a chatbot using OpenAI API/Dialogflow. Mobile applications have emerged as a convenient and accessible means to manage various health conditions, including tinnitus [8]. The purpose of this project is to provide the best techniques for managing tinnitus with the scope mention bellow: In Scope: Tinnitus severity assessment through user inputs and hearing test, Sound therapy and therapeutic exercises tailored to user needs, Realtime AI-based chatbot for assistance, Local storage of user data using SQLite, Referrals to healthcare professionals in severe cases. Out of Scope: Integration with health devices, Not available for iOS. Limitations: The app is not effective if the user inputs correct information, Change in hearing sound will affect user outcomes. Assumptions Constraints Assumptions: For assessing tinnitus the user will provide correct input,During development chatbot will remain accessible, When needed, the healthcare specialist will respond to referrals. Constraints: Limited by the mobile platform (Android) used for development, Dependence on SQLite for local data storage, without cloud integration, The free tier of chatbot APIs will be used due to budget constraints. Social Benefits The Tinnitus Management and Alleviation Hub objective is to provide many social benefits: Improved Quality of Life: To improve the quality to life the users will use the app to reduce the impact of tinnitus, Increased Awareness: Individuals will get awareness

to go and see a doctor whenever necessary,Promotes Mental Wellbeing: With the help of personalized sound therapy and CBT exercises, people with tinnitus will get relief of tinnitus and their mental health will also improve, Cultural Sensitivity: For sound therapy, nasheeds are recommended to Muslims so that tinnitus can be reduced.

I. LITERATURE REVIEW

Tinnitus, often referred to as a persistent "ringing in the ears," affects a large number of individuals around the world. It can interfere with daily activities, concentration, sleep, and overall mental health. According to the World Health Organization, approximately 15

Sound therapy involves introducing external soothing sounds to mask or distract from the internal tinnitus noise, while CBT helps patients manage emotional distress and negative thought patterns associated with the condition [1]. These therapies, while useful, are not always effective for every patient, and the need for more personalized and accessible solutions continues to grow [4], [16].

In countries like Pakistan, limited awareness and poor accessibility to proper tinnitus diagnosis and treatment often lead to the condition being ignored or mismanaged [11]. Patients in rural or under-resourced areas may go untreated due to the absence of specialists and therapeutic services. In recent years, mobile health (mHealth) applications have emerged as an innovative solution, offering structured and user-friendly access to various treatment options [8], [10].

A landmark randomized controlled trial evaluated a smartphone-based CBT and customized sound therapy, showing significant improvements in the Tinnitus Functional Index (TFI), anxiety, depression, and sleep quality after 8 weeks compared to a wait-list control [2]. Another pilot study using CBT-based mobile training demonstrated large-effect reductions in tinnitus handicap scores, with half of participants achieving reliable clinical change within just two weeks [3]. A long-term 9-month RCT using the Kalmeda app confirmed sustained benefits, including mid-term effect sizes of 0.6 and 0.68 on stress and depression scores, respectively [8]. Numerous studies reinforce the positive impact of app-

based sound therapy. A mixed-design study with the ReSound app found a 14.5-point mean reduction in THI over six months, with 39

Systematic reviews reinforce that CBT remains the bestsupported psychological treatment for tinnitus, while soundbased interventions show only limited evidence on their own [16]. Tinnitus Retraining Therapy (TRT), which combines counseling and sound enrichment, may offer modest benefits compared to masking alone—but the evidence base remains mixed [17], [19]. A comparative study conducted in rural Pakistan further validated the clinical effectiveness of AIpowered CBT apps when therapist access was limited [15].

Moreover, novel multimodal approaches are emerging. A recent pilot study from Italy combined personalized sound therapy with electromagnetic stimulation and achieved a 73

Additionally, mobile health applications reduce the dependency on clinical visits, which can be time-consuming and costly for many individuals. By enabling users to manage their symptoms independently, such apps promote self- efficacy and regular engagement in therapy. The use of CBT in these platforms reinforces long-term behavior change, especially when it comes to managing emotional responses to tinnitus [13], [16]. Many users find it easier to perform CBT exercises in a familiar environment, rather than in a clinical setting [18]. Sound therapy, when combined with guided CBT practices, has shown promising results in reducing the perceived intensity of tinnitus over time [6], [7]. Furthermore, the integration of chatbots provides users with an accessible source of guidance and reassurance. This immediate support plays a significant role in reducing anxiety, which is known to worsen tinnitus symptoms in many cases [12], [14].

This study proposes the development of the Tinnitus Management and Alleviation Hub, a mobile application designed to overcome the limitations of current solutions. The app integrates sound therapy,

CBT exercises, and an AI- powered chatbot to deliver tailored, interactive, and real-time support. It particularly focuses on users in underserved areas who are unable to access traditional care. The literature clearly shows that while mobile solutions for tinnitus are growing, there remains a significant gap in personalization, accessibility, and emotional support—issues this project aims to directly address.

REQUIREMENTS ANALYSIS

The development of the Tinnitus Management and Alleviation Hub mobile application involves several key stakeholders who influence, utilize, and contribute to the overall design and purpose of the app. Their roles are crucial in shaping the functionality, usability, and success of the system. Tinnitus Patients: These are the primary users of the application who suffer from varying degrees of tinnitus symptoms. The app is specifically designed to cater to their needs by offering supportive tools such as cognitive behavioral therapy exercises, soothing audio therapy, and access to chatbot-based guidance. Patients will regularly engage with the application to complete assessments, access therapeutic content, and monitor their condition. Their continuous feedback and usage patterns are vital in refining the app's performance and interface over time. Healthcare Providers: This group includes audiologists, psychologists, ENT specialists, and therapists who may not directly use the application themselves but will recommend it to their patients as part of a holistic management plan. Their expert insights on the effectiveness of CBT, therapeutic sound usage, and patient behavior play a significant role in guiding the design of app modules. These professionals may also help validate the clinical relevance of the features being offered. App Development Team: The technical team holds the responsibility of planning, designing, developing, testing, and maintaining the mobile application. This team consists of developers, UI/UX designers, testers, and project managers who work collaboratively to transform user requirements and clinical recommendations into a functional and secure digital platform. Their role also includes optimizing performance, ensuring compatibility across devices, managing security, and integrating third-party APIs such as AI chatbot services.

A. Requirements Elicitation

To ensure that the app fulfills the expectations of its endusers and clinical advisors, a thorough requirements elicitation process was conducted using both qualitative and quantitative techniques.

Interviews with Healthcare Professionals: A series of structured and semi-structured interviews were conducted with healthcare experts, especially audiologists and CBT practitioners. These interviews helped gather detailed insights into the treatment of tinnitus using behavioral strategies and sound therapies. The purpose was to understand how cognitive therapy interventions could be adapted into a mobile format and what essential features would make it effective for users.

User Surveys and Feedback Forms: Targeted surveys were distributed to potential users, primarily those experiencing chronic tinnitus, to understand their needs, struggles, and preferences when using health-related applications. These surveys gathered data on app usability expectations, content preferences (like sounds, nasheeds, or exercises), desired chatbot functions, and overall app accessibility. The results were analyzed to derive common themes and usability goals, which were directly incorporated into the app design.

B. Functional Requirements

The application is designed to deliver essential tinnitus management services in a personalized and accessible manner through various functional modules. CBT Exercise Delivery Based on Individual Needs: After assessing a user's tinnitus severity, the app generates a set of CBT exercises tailored to their level of distress. These include thought-recording, relaxation techniques, and focus-shifting methods. The goal is to ensure that therapy remains context-specific, providing relevant support based on user responses. Therapeutic Sound Playback: Depending on the severity of the user's symptoms, the

application provides a curated selection of sound therapies—such as nature sounds, instrumental music, or spiritual nasheeds—that aid in masking tinnitus and calming the nervous system. These are categorized and offered dynamically based on assessment scores.

C. Non-Functional Requirements

In addition to core functionalities, the application is expected to meet several non-functional criteria that ensure robustness, security, and user satisfaction. Performance and Speed: The app must load quickly, even when handling large datasets, user profiles, or audio content. Operations such as navigating between screens, initiating sound therapy, and loading AI responses should occur without noticeable delay. User Interface and Usability: The application must have a clean, responsive, and intuitive interface that caters especially to users who may not be familiar with advanced technology. Clear buttons, guided instructions, and minimal steps in each process are essential for effective use. Data Security and Privacy: User data—especially health-related data such as test results and therapy history—must be encrypted and securely stored. The application must comply with relevant data protection principles to ensure that personal and medical information is not accessible by unauthorized parties. Scalability and Reliability: The system should be capable of handling increased traffic without crashing. Whether multiple users are logged in simultaneously or large volumes of data are processed, the app must maintain stability and provide consistent results.

II. SYSTEM ARCHITECTURE

The Tinnitus Management and Alleviation Hub application is developed with a robust architecture that prioritizes seamless performance, scalability, data consistency, and a user-centered design. The architecture ensures that all modules work in harmony to deliver reliable and efficient functionality. It also supports the adaptability and future enhancement of the system, ensuring long-term sustainability. This architectural setup ensures that users from various technological backgrounds can access the app smoothly while maintaining high responsiveness and data integrity across all devices.

A. Hardware Components

The application is specifically built to operate efficiently on modern Android smartphones. It supports devices running Android version 8.0 (Oreo) or higher, ensuring compatibility with the majority of currently used Android platforms. This version and above provide the necessary system capabilities, permissions, and optimization support for background processing and media playback. For optimal performance, a minimum processor speed of 2.6 GHz is recommended. This ensures smooth multitasking, real-time audio streaming for sound therapy, and seamless chatbot interactions. Additionally, a minimum of 4 GB RAM is advised to allow the application to run without lags or freezing, especially during sound playback or AI-based operations. For storage, users should have at least 2 GB of free internal memory available. This space is required for the installation of the app, storage of local data such as test results, and caching of therapy-related audio content. Efficient memory management ensures the app does not compromise the performance of the mobile device during long-term use.

B. Software Components

The development of the Tinnitus Management and Alleviation Hub is carried out using Android Studio, which serves as the primary integrated development environment (IDE) for coding, testing, debugging, and deploying the application. Android Studio offers powerful tools like the emulator, build variants, and Gradle support which streamline development and testing across multiple Android devices and API levels. For data management, the app employs SQLite, a lightweight, embedded database system that stores user credentials, test scores, and therapy history locally on the device. This ensures ofline availability and fast read/write operations, which are crucial for mobile performance. Furthermore, the OpenAI API and/or Google Dialogflow is integrated

to support the intelligent chatbot, enabling real- time natural language processing (NLP) to address user queries effectively. The chatbot assists users in understanding their tinnitus conditions and suggests therapy options accordingly. SQLite also plays a critical role in ensuring secure data storage and user session management, which allows for smooth transitions between modules and reduces the need for repetitive inputs by returning users.

C. Architectural Design

The system adopts a modular and layered design structure, built upon the Model-View-Controller (MVC) architectural pattern. This pattern allows the separation of concerns, ensuring that the application is easy to maintain and extend.

Model: The model is responsible for handling all datarelated logic, including the retrieval and storage of data in the SQLite database. It processes user responses to the THI questionnaire and hearing test results, computes tinnitus severity scores, and manages therapy history records. By isolating data operations, the model ensures data consistency and simplifies backend processes.

View: The view represents the user interface layer of the application. It includes intuitive screens for user registration, login, questionnaire input, hearing test feedback, sound therapy, CBT guidance, and chatbot conversations. Each screen is designed with usability in mind, ensuring clear navigation and accessibility for users of varying ages and technical proficiency.

Controller: Acting as the bridge between the model and view, the controller receives input from the user, applies business logic, and updates the view accordingly. It manages interactions such as user authentication, test initiation, score calculation, and sound playback. The controller also handles communication with external services like the OpenAI API to fetch AI chatbot responses in real time. This layer ensures dynamic system behavior and smooth user interaction.

D. Integration Overview

The application's architecture ensures that each core module functions independently yet integrates seamlessly to provide a cohesive experience.

The hearing test module operates by presenting a sequence of predefined frequency tones to the user. Based on the responses to each tone, the module calculates the user's hearing threshold across various frequency ranges. These results are stored in the local database for future analysis and therapy adaptation.

The analysis module plays a central role in synthesizing data. It takes the output from the hearing test and the THI questionnaire, merges both data sets, and computes an overall tinnitus severity score. This score then informs which therapy recommendations will be shown to the user.

The therapy module uses the severity data to offer appropriate CBT exercises and soothing sound files tailored to the user's needs. For instance, users with mild symptoms might receive general relaxation sounds, while those with moderate or severe symptoms may receive targeted therapy suggestions.

The AI chatbot module integrates with OpenAI or Dialogflow to offer real-time conversational support. Users can type their queries, and the chatbot responds with helpful information, tips, or guidance. This feature enhances the app's accessibility and usability, especially for users unfamiliar with tinnitus treatment.

Lastly, in cases of severe or catastrophic tinnitus severity, the app offers a referral feature that lists manually curated healthcare professionals from the local area. This information is displayed from a preloaded in-app database without any external map links. The inclusion of local doctors ensures that users are not left unsupported, especially when selfmanagement may not be enough.

This integrated design approach ensures each component works both independently and collaboratively to provide an effective, user-focused tinnitus management experience.

III. SOFTWARE DEVELOPMENT MODEL

The Incremental Software Development Methodology will be implemented for Tinnitus Management and Alleviation Hub. This approach calls for incremental build-up of the system by dividing the project into other projects delivering an aspect of the system in a form of an increment. This

entails comprehensively performing analyzing and documenting core requirements and going ahead to design and implemented user interfaces and sound therapy features and other modules' design in the latter supposed steps. Each of these increments will then be thoroughly tested before they are incorporated into the aggregate system. This allows for earlier on short delivery of functional components, completion of systems in state where it is possible to make further development, test, and allow any conforming changes. Comprehensive evaluation of the system will deal with setting up of the system and determine if it satisfies users' needs and the goals of the project.In this approach system is divided into smaller independent components that will perform specific tasks. Every module is developed and verified independently which makes debugging and testing easier. Moreover, it improves scalability and encourages code reusability. The modular design will guarantee that each module is designed to perform a specific function. To understand the user's tinnitus condition the Input Module will collect user data through questionnaires and hearing tests. The Analysis Module will process the data and identify the degree of user tinnitus. On the basis of analysis, the Therapy Module will suggest personalized sound therapy and therapeutic exercises according to the user's needs. Furthermore, the Chatbot Module will offer AI-driven support by answering user queries. Based on the user location Referral Module will connect users with severe tinnitus or injury in the ear or head, to nearby healthcare professionals to provide extensive support.In incremental approach system is built gradually, at each stage a new feature is added. The process contains requirement analysis, and individual components are designed and developed after testing they are integrated with parts that are previously completed. This model has several benefits, such as the ability to deliver functional components, simplification of debugging and integration, and allowing flexibility for later modification. Users will evaluate their tinnitus condition with the initial delivery of the severity questionnaire and assessment module. After that the user can access the sound therapy and cognitive behavioral exercise features, enabling therapeutic solutions for users. System also contains AI chatbot to offer support. Lastly, the doctor referral system will be included which help users to connect with healthcare professionals to seek specialized care.

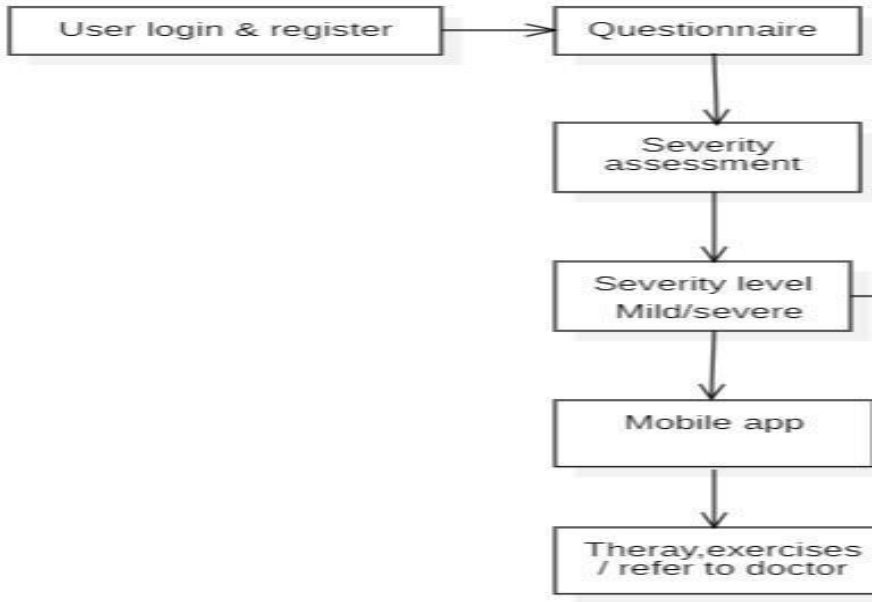

Fig. 2. Flow of tinnitus management and alleviation hub.

PROPOSED FRAMEWORK

The Tinnitus Management and Alleviation Hub is a comprehensive mobile-based solution designed to provide relief and structured support to individuals affected by tinnitus. This application integrates various therapeutic components, such as sound therapy, cognitive behavioral therapy (CBT) exercises, and conversational support through an AI-powered chatbot. These components are unified under a single digital framework, enabling users to manage their condition effectively from the comfort of their homes. The goal of this system is to bridge the existing gap between traditional in-clinic tinnitus treatments and accessible, digital therapeutic approaches by providing a self-guided, evidence-informed management tool. Through this app, users are empowered to assess their condition, access guided therapy modules, and seek support in real-time, ultimately leading to improved emotional resilience and symptom control.

The mobile application's primary focus is to offer a structured approach to tinnitus management by guiding users through key stages of self-evaluation and treatment selection. By assessing the user's tinnitus severity level using standardized metrics such as the Tinnitus Handicap Inventory (THI) and auditory screening, the app can determine the intensity of the user's condition and propose personalized therapeutic interventions accordingly. These interventions are not generic; rather, they are tailored to the specific degree of discomfort reported by the user, ensuring greater relevance and effectiveness. Furthermore, the app maintains user data locally using a secure database, ensuring continuity in therapy and access to previous results without compromising user privacy.

The inclusion of an AI-powered chatbot provides a unique layer of interactivity and support. This chatbot, integrated through technologies like OpenAI or Dialogflow, is capable of addressing user queries, clarifying therapy procedures, and offering reassurance through real-time communication. The chatbot serves not only as a source of information but also as a virtual assistant, guiding users through therapy protocols and helping them stay consistent with their treatment plans. This feature is particularly beneficial for users who may not have immediate access to healthcare professionals or who require emotional support during therapy.

By combining CBT-based exercises, soothing auditory stimuli, and interactive communication, the framework offers a multifaceted therapeutic experience. CBT content includes relaxation techniques, cognitive reframing activities, and daily coping strategies, which have been clinically shown to reduce the psychological impact of tinnitus. Sound therapy modules include various tones, nature sounds, and calming nasheeds, all aimed at masking tinnitus noise and enhancing auditory comfort. These modules are delivered based on the tinnitus severity classification, ensuring that each user receives an optimal combination of support tools.

Another strength of this framework is its simplicity and user- friendly design. The interface is intuitive and structured in a way that even non-technical users can easily navigate between modules. Users can begin with a straightforward login/signup system, proceed to take a hearing assessment and questionnaire, and subsequently access appropriate therapies without requiring any professional supervision. The system ensures that every session is logged and user progress is saved, allowing continuity even after app restarts.

In addition, the application reduces dependency on costly or inaccessible treatments by providing all features ofline after initial setup. This is especially beneficial for individuals in rural or underserved areas who may not have access to specialized tinnitus care. Manual entries of local healthcare professional contacts ensure that those with severe symptoms can be directed toward appropriate ofline care without needing complex geolocation or live APIs.

Ultimately, the proposed framework ensures comprehensive support throughout the user journey—from the moment they assess their condition to engaging in therapeutic interventions and seeking guidance through the chatbot. This

integrated model of care not only enhances usability and engagement but also aligns with modern trends in personalized and preventative digital healthcare.

A. User login and sign up

The first interaction between the user and the application occurs through the login or sign-up process. New users are prompted to register by providing essential credentials such as email and password. Upon submission, the system validates the uniqueness of the email against entries in the Users table. If the email is already registered, the user is notified to use a different one. If the email is found to be unique, the user data is securely stored in the database, enabling account creation. For returning users, the login module collects their email and password and cross-verifies these credentials with existing entries in the Users table. Upon successful authentication, the system sets the currentUser session and transitions the user to the main interface of the app. This workflow ensures that every individual receives a personalized experience based on their stored information and progress.

B. Questionnaire

The core of the tinnitus assessment in this application is based on the Tinnitus Handicap Inventory (THI), which is widely accepted for evaluating the psychological and functional impact of tinnitus on an individual's life. The questionnaire consists of 25 questions, each designed to capture specific dimensions of the user's emotional, social, and physical response to tinnitus. Unlike the traditional 3-point response scale, the application uses an expanded five-point Likert scale to obtain more nuanced user feedback. The available options include: "Always" (score = 4), "Often" (3), "Sometimes" (2), "Rarely" (1), and "Never" (0). This fine- grained scale enables a more detailed analysis of the user's condition, providing therapists and users themselves with greater insight into the intensity and frequency of tinnitus- related issues. The total score is computed by summing the values of all selected responses.

C. Severity Assessment

Once the user completes the questionnaire, the system evaluates the severity of tinnitus based on the cumulative score of all 25 responses. Each answer contributes to a total score out of 100, which is then used to categorize the user's level of tinnitus-related handicap. These levels are structured as follows: 0–16: No handicap, 18–36: Mild handicap, 38–56: Moderate handicap, 58–100: Severe handicap The app uses this categorization to better understand the extent of impact on the user's daily functioning and emotional stability. This assessment not only aids in diagnosis but also guides the subsequent therapy recommendations. By offering a structured scale, the app allows both users and healthcare providers to track symptom progression or improvement over time.

D. Severity Level

After the total score from the THI questionnaire has been computed, the app determines the severity level of tinnitus using a slightly different four-level scale tailored to its internal logic. Based on this system: A score between 0–25 is interpreted as Mild, 26–50 as Moderate, 51–75 as Severe, and above 75 as Catastrophic. This further refined breakdown helps differentiate not just the presence of symptoms but their seriousness and urgency. The calculated severity level is then stored, along with the total score and the user's unique identifier, in the UserResults table of the local SQLite database. This storage allows the application to offer tailored content in future sessions and ensures that each user receives ongoing, personalized care based on their latest self-assessment.

E. Therapy Recommendation

Based on the severity level derived from the THI assessment, the application dynamically recommends therapy options. For users falling

within the Mild or Moderate categories, the app suggests access to therapeutic sound libraries (including calming natural sounds), spiritual nasheeds for relaxation, and guided CBT exercises aimed at alleviating anxiety and negative thinking patterns associated with tinnitus. These interventions are selected to be non-invasive and userfriendly while promoting relaxation and cognitive reframing. For users assessed with Severe or Catastrophic tinnitus, the app issues a recommendation to consult a doctor for professional evaluation and treatment. In addition, the app still provides access to sound therapy and CBT exercises to offer temporary relief and emotional support. These users are shown a curated list of doctors already stored in the system database based on locality, allowing them to reach out for further help even without internet-based referrals. This therapeutic recommendation module ensures that each user receives context-sensitive interventions according to their condition's intensity.

IV. HEARING TEST AND THI QUESTION

Tinnitus, often accompanied by hearing anomalies or distortions, may be linked to hidden hearing loss or auditory processing disorders. These symptoms include the perception of phantom sounds, such as ringing, buzzing, or humming, in the absence of any real external stimuli [10]. To assess a user's auditory health and its possible contribution to tinnitus symptoms, the Tinnitus Management and Alleviation Hub integrates a Pure-Tone Hearing Screening module. This module simulates an audiometric test by playing specific frequencies through the user's device to evaluate the hearing response.

The hearing test is structured to assess tone detection at six standard audiological frequencies: 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz. After each tone is played, the user is prompted with the question: "Can you hear this sound?". The available response options are simple: "Yes, I heard it" or "No, I did not hear it." Each response is recorded in the system, enabling a basic yet informative evaluation of the user's hearing sensitivity. If the user answers "Yes" to all frequencies, hearing is considered to be within normal range. However, a "No" response to any specific frequency indicates a possible hearing deficit, especially in that frequency range, prompting a recommendation to consult a professional audiologist for further evaluation.

In addition to the hearing test, the app integrates the Tinnitus Handicap Inventory (THI) to assess the psychological and functional burden of tinnitus. This inventory includes 25 carefully designed questions, each targeting a specific dimension of the user's response to tinnitus, including emotional distress, daily activity interference, concentration difficulties, and social withdrawal [2]. To improve user interaction and collect more precise information, the original three-point scale is replaced by a five-point Likert scale, where responses range from "Never" (0) to "Always" (4). Each response is scored accordingly, and the total score—ranging from 0 to 100—is calculated.

This score is then interpreted using predefined ranges to determine the user's severity level: 0–25: Mild, 26–50: Moderate, 51–75: Severe, ¿75: Catastrophic Once calculated, the total score is stored in the local database for reference. This score not only aids in personalizing therapy content but also serves as a baseline for future comparisons, helping the user and healthcare providers monitor changes in tinnitus impact over time.

V. ALGORITHM WORKING

Start the application. Upon launching the application, the system initializes the local SQLite database and ensures the creation of all essential tables, including Users, Questions, UserResults, and TherapyHistory. Necessary libraries for database management, media playback (for sound therapy), location access, and network communication are imported at the beginning. Key variables such as currentUser, severityLevel, and a structure for storing userResponses are declared to manage the app's flow and state. The application

begins by prompting the user with two options: Sign Up or Login. If the user selects Sign Up, the system requests an email and password. It then verifies whether the email already exists in the Users table. If the email is unique, the new user's data is stored in the database, and account creation is confirmed. If the user selects Login, they are prompted to enter their existing credentials, which are validated against the stored entries in the Users table. Upon successful authentication, the currentUser is set, and the user is redirected to the main interface. Once logged in, the application presents a menu with the following options: Take Tinnitus Assessment, Access Therapy, Chat with AI Bot, Find Nearby Doctors, View Previous Result, and Logout. These options remain available in a loop until the user chooses to log out. When the user selects Take Tinnitus Assessment, the application loads a predefined questionnaire from the Questions table. Each question is displayed individually, and the user provides a response to each one. Once the questionnaire is completed, a total score (totalScore) is calculated based on all responses. The resulting score and severity level are stored in the UserResults table alongside a timestamp and user identifier. This score reflects the current state of the user's tinnitus symptoms. If the user selects Access Therapy, the app first retrieves the latest severity level for the user from the UserResults table. If the severity is categorized as Mild or Moderate, the application provides access to a range of therapy content, including soothing sound clips, nasheeds, and CBT exercises. These are presented in the form of audio or guided exercises aimed at relaxation and mental relief. If the severity level is Severe or Catastrophic, the application advises the user to seek medical attention and still provides therapy options to offer temporary support. Upon selecting an audio or therapy session, the file is loaded from the app's resources and played using the MediaPlayer utility. The session information, including the user ID, therapy type, and duration, is recorded in the TherapyHistory table. If the

Response	Score
Always	4
Often	3
Sometimes	2
Rarely	1
Never	0

Fig. 3. responses and scores of questionnaire.

user selects Chat with AI Bot, the system starts an interactive session that allows the user to type and send questions or messages. These messages are sent to an integrated AI model via API, and the responses are displayed in real-time. All conversations are saved locally using SharedPreferences for reference and ofline availability. This feature supports user engagement and provides real-time assistance in addressing queries related to tinnitus. When the user selects Find Nearby Doctors, the application retrieves a manually curated list of doctors specific to the user's city or region. These entries are stored locally and contain relevant details such as name, specialization, and contact number. The doctors are listed within the app interface, offering the user basic ofline access to professional contacts without any external linking or API dependency. By selecting View Previous Result, the user can see only their most recent tinnitus assessment result.

This includes the latest total score and the determined severity level, allowing them to keep track of their current condition without accessing a full history log.

Finally, if the user selects Logout, the application clears the currentUser session data and redirects the user back to the login screen, concluding the active session. All data during the session is backed up locally to ensure availability during ofline usage and to preserve continuity upon next login.

VI. SYSTEM TESTING

The Tinnitus Management and Alleviation Hub application underwent rigorous testing to ensure its reliability, accuracy, and user experience. A combination of manual and observation-based approaches was used to evaluate core functionalities, integration flow, and the overall behavior of the user interface. Each testing phase was designed to validate the application against both typical and edge-case scenarios.Manual testing was employed throughout development to detect usability issues and bugs early in the process. By simulating real user interactions without automation tools, testers were able to observe how the system responded under various conditions.Types of Manual Testing Performed are System Testing, Unit Testing, Functional Testing, Integration Testing.Each type of testing focused on different levels of the application, ensuring comprehensive validation of both individual modules and the complete system. A field usability test was also carried out with university students. Custom forms were printed, and students used the app to complete the tinnitus severity assessment. Afterward, they provided feedback through a questionnaire, rating the clarity of the questions and the perceived accuracy of their results. This real-world input led to improvements in the wording and presentation of the assessment. Additionally, expert validation was obtained from an ENT specialist at Aziz Fatima Hospital, Faisalabad. The specialist evaluated the sound test module and the questionnaire, confirming that the structure and logic used to estimate severity levels aligned with clinical practices. System testing verified the application as a whole against the specified requirements. Test Scenarios and Cases are: User launches the app → splash screen appears, User signs up with valid/invalid email, Logged-in user accesses dashboard, User completes the tinnitus questionnaire and receives accurate severity results, Correct sound therapy is offered based on severity, Chatbot receives and responds to user queries, Referral system shows appropriate doctors based on location.Issues Identified are: Chatbot occasionally failed to
respond on slow networks, Minor UI overlaps on low- resolution devices.All issues were resolved by adjusting code and optimizing response handling. Unit testing focused on individual modules such as:Signup and Login logic,Questionnaire score calculator, MediaPlayer initialization, SQLite CRUD operations, Tested each function separately using mock inputs, Ensured proper handling of null or invalid values. Outcome contains 100% pass rate for individual modules, Helped isolate logic bugs in the assessment and therapy modules Functional testing validated that all key functionalities were working as expected. Functional Test Cases includes: F1: Register a new user with valid inputs → Success, F2: Log in with incorrect password → Show error, F3: Complete THI questionnaire → Show result, F4: Access therapy → Play relevant audio, F5: Chat with bot → Response received, F6: View doctor list based on city → Show matching entries Challenges Faced were: Initial audio loading lag in therapy module (resolved with preload strategy), Emoji options sometimes clipped on small screens (fixed by adjusting layout constraints) Integration testing ensured seamless interaction between modules. Tests Conducted are Authentication → Home Screen → Assessment → Therapy, Questionnaire Result
→ Severity Calculation → Therapy Recommendation, Chatbot Network API Response Display.Issues Found were: Data inconsistencies when switching rapidly between modules, SharedPreferences not updating on

logout (resolved). Automated testing was not conducted using external frameworks like JUnit or Espresso. Instead, the development team utilized Android Studio's Logcat console to debug the application and track runtime issues. Tool Used were: Logcat (Android Studio Debug Console) its Purpose is to Identify runtime errors, crashes, and debug messages during development. it Used Log.d() and Log.e() statements to trace flow and identify crashes, Verified user authentication, media playback, and questionnaire logic.its Benefit is to Provided real-time diagnostics without the need for external libraries or automation tools.

VII. Problems Faced

During the development of the Tinnitus Management and Alleviation Hub, several technical and logistical challenges were encountered. One of the primary difficulties involved integrating multiple modules—such as sound therapy, chatbot functionality, and doctor referrals—into a single Android application without compromising performance. This required careful resource optimization, particularly in managing media files and addressing network delays associated with the chatbot. Ensuring the medical accuracy of the questionnaire was another major hurdle. Initially developed using general knowledge of tinnitus, the questionnaire underwent multiple revisions following expert feedback from an ENT specialist to ensure alignment with clinical standards. Additional challenges emerged during the debugging phase, especially when handling SQLite database operations and resolving errors related to the MediaPlayer component. The use of Logcat proved instrumental in identifying and resolving these issues. On the user interface side, maintaining responsive layouts across different screen sizes proved complex, particularly when incorporating emojis and card views. Despite these obstacles, the project provided valuable insights into user-centered design, Android debugging strategies, and the critical role of early consultation with domain experts. The development process also enhanced collaboration skills and built greater confidence in testing and iterative improvement.

VIII. RESULTS AND DISCUSSIONS

The testing process revealed and resolved multiple minor bugs, leading to a stable and reliable application.Test Metrics are the Unit test success rate: 100%, Functional test success rate: 96%,Integration test success rate: 98%, System test success rate: 95%, Field testing approval (students): 92% rated the app's assessment as accurate or very accurate. The ENT Specialist Feedback: Confirmed clinical relevance of severity logic and usability for patients Key Achievements includes the Stable performance across Android devices with Android 8.0+, Accurate severity detection and therapy recommendation, Real-time chatbot functionality working in limited bandwidth conditions. The Areas Improved Post-Testing are:Optimized image and sound file sizes to improve load time, Enhanced questionnaire layout with responsive emoji options Added retry logic for chatbot responses.The testing cycle has confirmed that the application fulfills its intended purpose, offers an accessible and user-friendly interface, and operates reliably across its major components.

Total Score	Severity Level
0–16	No handicap
18–36	Mild handicap
38–56	Moderate handicap
58–100	Severe handicap

Fig. 4. access severity level

IX. LIMITATIONS

There are 3 Limitations of the Project Despite the project's success, several limitations impacted its scope and effectiveness: Limited Platform Support: The app was developed exclusively for Android. Users on iOS platforms are currently unable to access the app, No Cloud Integration: Data is stored locally using SQLite, which limits data sharing and remote backup features,Internet Dependency for Chatbot: The AI chatbot requires a stable internet connection to function. Ofline support is not available, Manual Doctor Data: Doctor referral information was added manually and may become outdated without dynamic updates, Subjective Responses: The accuracy of the tinnitus severity test depends on honest and accurate responses from users. These limitations were primarily due to time constraints, limited resources, and the scope of an undergraduate project.

X. CONCLUSION

The Tinnitus Management and Alleviation Hub successfully achieved its key objectives. The mobile application provides users with an all-in-one platform to manage tinnitus through features such as sound therapy, CBT-based exercises, AIpowered chatbot assistance, and referral support for more severe cases. Alongside technical development, the app was validated through clinical feedback and usability testing conducted with university students. A modular design approach was followed, ensuring that each component—assessment, therapy, chatbot, and referral system—functioned independently while maintaining overall integration. Personalized sound therapy options and culturally appropriate content, including nasheeds for Muslim users, contributed to the app's accessibility and inclusiveness. A certified ENT specialist reviewed the questionnaire to confirm its medical relevance, and most student participants reported that the results they received were accurate and helpful. Overall, the project presents a practical and scalable solution to a commonly overlooked health concern. It holds significance not only in academic settings but also in offering meaningful value at a social and healthcare level.

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