PHRAJ
Public Health Risk Assesment Journal
PHRAJ 2(2): 102-117
ISSN 3025-1109

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

EmoTrack headset and smart application: An integrated solution for emotional regulation and mental health support in Indonesia's 5.0 modernization era

Siti Naila Nafisya[1]
[1] *Department of Pharmacy, Faculty of Health Science, Universitas Islam Negeri Syarif Hidayatullah, Jl. Kertamukti No. 5 Pisangan Ciputat, South Tangerang City 15419, Indonesia.*
*Correspondence: siti.nailanafisya21@mhs.uinjkt.ac.id

Received Date: December 12, 2024 Revised Date: January 31, 2025 Accepted Date: January 31, 2025

ABSTRACT
Background: Mental health issues are increasingly prevalent in Indonesia, with limited resources, social stigma, and insufficient community awareness posing barriers to effective management. **Methods:** This study introduces the EmoTrack Headset-App, a novel, integrated self-therapy device combining transcranial direct current stimulation (tDCS) and binaural beat technology to support mental health and emotional regulation. This solution enables real-time mental health monitoring and offers tailored interventions through a wearable headset linked to a smartphone application. Data collection involved a literature review and device prototyping to assess the feasibility and potential impact of EmoTrack. **Findings:** Results indicate that tDCS and binaural beats enhance emotional stability and reduce symptoms of anxiety and depression. Additionally, the app's community feature facilitates user engagement, helping to destigmatize mental health issues and encouraging shared experiences. **Conclusions:** The EmoTrack system has the potential to revolutionize mental health care by improving access to preventive and therapeutic support in Indonesia. **Novelty/Originality of this article:** This innovation uniquely combines tDCS and binaural beats within a single device, presenting a pioneering tool that addresses mental health and emotional regulation in a wearable, user-friendly format.

KEYWORDS: mental health, tDCS, binaural beats.

1. Introduction

Mental health disorders are a growing global issue that has garnered increasing attention due to their rising prevalence. Mental disorders are part of neuropsychiatric and psychological dysfunctions that encompass various health conditions affecting mood, thoughts, and behaviors (Dewanto, 2009). These disorders range from depression and anxiety to bipolar disorder and schizophrenia, each with unique impacts on individuals' lives and overall well-being. In Indonesia, the prevalence of mental disorders in individuals aged 15 and above has reached over twenty million people (Kemenkes RI, 2021). Outside these estimates, many cases of mental disorders remain undiagnosed or unreported, especially in remote areas. This substantial figure reflects the challenges in managing and addressing mental health issues in Indonesia, exacerbated by a shortage of resources, limited access to remote areas, and a lack of awareness and education on mental health (Febriandi, 2023). The lack of awareness contributes to the substantial gap between mental

Cite This Article:
Nafisya, S. N. (2025). EmoTrack headset and smart application: An integrated solution for emotional regulation and mental health support in Indonesia's 5.0 modernization era. *Public Health Risk Assesment Journal, 2*(2), 102-117. https://doi.org/10.61511/phraj.v2i2.2025.1392

health care needs and available services, particularly in under-resourced regions where facilities and personnel are limited.

Government efforts, particularly by the Ministry of Health and various non-governmental organizations such as the Schizophrenia Care Community of Indonesia and the Pulih Foundation, have included programs for mental health services and expanding mental health service networks (Febriandi, 2023). However, according to Sehatnegeriku (2022), these initiatives face significant limitations. The Ministry's programs lack specific focus on mental health, and the non-governmental programs are often under-coordinated and poorly disseminated to the public. This gap highlights a pressing need for structured mental health support systems. Moreover, mental health education remains limited, and pervasive stigma still surrounds mental health disorders in Indonesian society. Mental health conditions are frequently associated with superstitions, such as beliefs in spirits or curses, and are often viewed as a sign of weak spirituality or lack of closeness to God (Dewanto, 2009). This stigma prevents individuals from seeking appropriate treatment, leading to a worsening of their mental health status. For instance, studies reveal that many underage individuals suffer from depression and anxiety without parental knowledge, preventing them from accessing necessary care. This lack of parental awareness and education further limits early intervention opportunities, leaving individuals without support for managing their mental health.

Neglecting mental health can have severe implications, not only for the affected individuals but also for society as a whole. Untreated mental health disorders can lead to decreased immune function, disrupted sleep patterns, and a heightened risk of chronic illnesses such as cardiovascular diseases (Dewanto, 2009). Socially, mental health issues can impair one's ability to work, engage in relationships, and enjoy daily life. In many cases, individuals with mental health disorders exhibit physical symptoms, such as shortness of breath or lower limb dysfunction, that require immediate medical attention (Dewanto, 2009). Therefore, it is critical to recognize mental health as a vital aspect of overall health and address it with the same urgency as physical health issues.

One of the leading causes of mental health disorders is the inability to manage and express emotions in a healthy way. Emotional dysregulation, such as excessive anger, deep sadness, or constant anxiety, can act as primary triggers for mental health disorders. When left unmanaged, these emotions can lead to destructive behaviors, such as substance abuse, and an increased risk of depression and anxiety. Effective emotional regulation is not simply about suppressing negative emotions; rather, it involves understanding, accepting, and channeling them positively (Dewanto, 2009). Developing these skills is essential to prevent more serious mental health problems in the future. Various methods have been found effective for managing emotions, such as mindful breathing, progressive muscle relaxation, and cognitive reframing. One of the most effective approaches to emotional regulation is self-administered psychotherapy, where individuals learn to understand their emotions and develop coping mechanisms. Psychotherapy serves as both a treatment and preventive approach for mental health issues, supporting individuals in processing their emotions in a healthy way and developing stronger coping strategies.

This study introduces a potential solution for addressing mental health issues and supporting emotional regulation: the EmoTrack Headset-App. This innovation integrates transcranial direct current stimulation (tDCS) and binaural beats technology, which has been shown to alleviate symptoms of mental health conditions such as depression, anxiety, schizophrenia, and bipolar disorder (Bennabi & Haffen, 2018; Stein et al., 2020; Cheng et al., 2020; D'Urso et al., 2023). Through modulation of neuronal excitability, tDCS can reduce addictive behaviors and enhance self-control. Binaural beats, generated when two different frequencies are presented to each ear, create a third sound associated with states of relaxation, targeting frequencies within the theta (4-8 Hz) and alpha (8-14 Hz) ranges (Baseanu, 2024; Shalforoushan & Golmakani, 2023). Studies show these frequencies are associated with relaxation and reduced negative emotions, which could be beneficial in treating anxiety, depression, ADHD, and sleep disorders (Pringgoutami & Perdani, 2017; Shalforoushan & Golmakani, 2023).

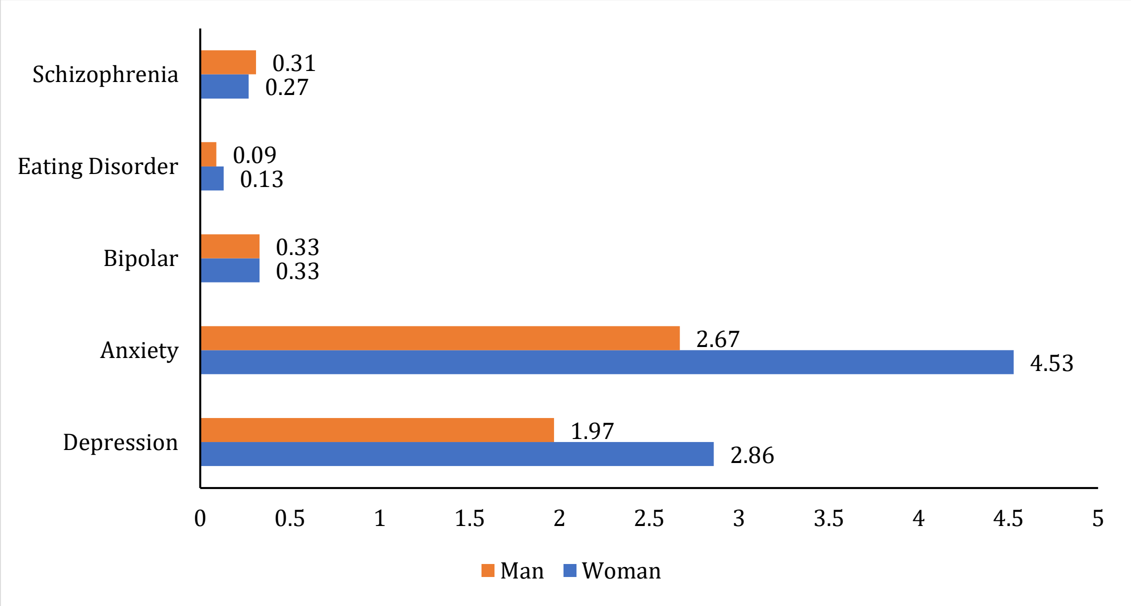

Fig. 1. Percentage of mental health disorder prevalention in Indonesia in 2019 (Roser et al., 2024)

2. Methods

This study employs a qualitative and experimental design to evaluate the feasibility and potential impact of the EmoTrack Headset-App as a mental health intervention tool. The study location focuses on Indonesia, a country with limited access to mental health resources and high prevalence of stigma, making it an ideal setting for evaluating EmoTrack's usability and effectiveness in this context. The research was conducted from October 2024 to address the specific social and cultural challenges in Indonesian mental health care, such as access in remote regions and community reluctance to seek psychological support due to stigma.

The EmoTrack Headset incorporates two primary technologies: transcranial direct current stimulation (tDCS) and binaural beats. The tDCS system uses electrodes placed on the scalp to deliver low-intensity currents (1–2 mA) that modulate neuronal activity, particularly targeting regions associated with impulse control and decision-making, such as the prefrontal cortex. This method is supported by prior studies (e.g., Bennabi & Haffen, 2018; Stein et al., 2020) that demonstrate tDCS's effectiveness in reducing symptoms of mental health disorders. Binaural beats, created by playing two slightly different frequencies in each ear, encourage brainwave states associated with relaxation, specifically in the theta (4–8 Hz) and alpha (8–14 Hz) ranges. These frequencies are connected to improved relaxation, emotion regulation, and anxiety reduction (Baseanu, 2024; Shalforoushan & Golmakani, 2023). The EmoTrack system consists of a lightweight, wearable headset integrated with a microprocessor, Bluetooth connectivity, and a smartphone application. The application connects to the headset, providing real-time feedback and data visualization for the user, as well as access to self-guided therapy options.

3. Results and Discussion

3.1 The Prototype

EmoTrack functions as an integrated self-therapy tool connected to telemedicine, aimed at detecting mental health issues, preventing relapses, and continuously monitoring patient conditions. EmoTrack is designed to provide substantial support not only for individuals facing mental health challenges but also for general users interested in learning to manage their emotions. The EmoTrack Headset integrates with an electronic service system, enabling remote monitoring and timely interventions. Designed as an ear-worn device, it offers comfort and ease of use, allowing for real-time detection and more effective medical decision-making. Additionally, the device is practical, stylish, and modern, in line with current trends. This tool has the potential to enhance the quality of life for individuals with anxiety and simplify mental health management for medical professionals.

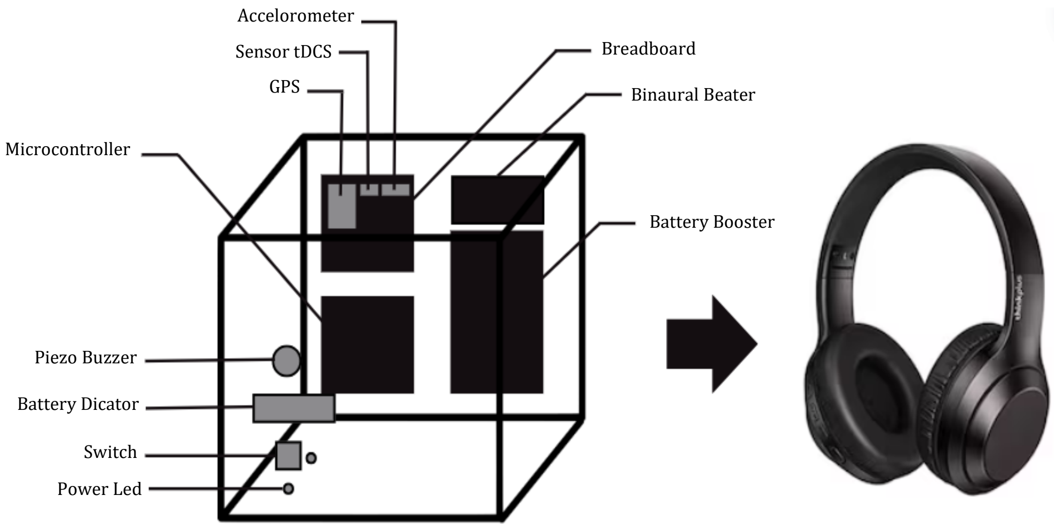

Fig. 2. Components of the emotrack headset and ear fitting

A major advantage of this headset is its use of transcranial direct current stimulation (tDCS) components along with binaural beat techniques. Transcranial direct current stimulation (tDCS) is a non-invasive neuromodulation technique involving administration of well-tolerated electrical current to the brain through scalp electrodes (Jog, 2023). This technique added to the standard arsenal of methods to alter brain physiology as well as psychological, motor, and behavioral processes and clinical symptoms in neurological and psychiatric diseases (Stagg et al., 2018). Currently, tDCS is a non-invasive method that applies low electrical currents (typically 1–2 mA) through electrodes on the scalp to modulate neuronal activity in areas of the brain associated with impulse control and decision-making, such as the prefrontal cortex. The application of tDCS has been shown to effectively address mental health issues such as depression, anxiety, schizophrenia, and bipolar disorder (Bennabi et al., 2018; Stein et al., 2020; Cheng et al., 2020; D'Urso et al., 2023). By enhancing or reducing neuronal excitability, tDCS can help decrease addictive behaviors and improve self-control. EmoTrack is also equipped with binaural beat technology. The principle involves playing two tones with slightly different frequencies through each ear; the brain responds by generating a third tone called a binaural beat. For example, if a 300 Hz tone is heard in one ear and a 310 Hz tone in the other, the brain perceives a beat at a frequency of 10 Hz (the difference between the two tones). Target binaural beats are set within the theta (4–8 Hz) and alpha (8–14 Hz) ranges, both of which are associated with a relaxed physical state, thereby minimizing negative emotional impulses. This technique has proven effective in addressing depression and anxiety (Baseanu, 2024), ADHD (Pringgoutami, 2017), and sleep disorders like insomnia (Shalforoushan, 2021).

Based on Das et al. (2016), non-invasive brain stimulation techniques, such as transcranial Direct Current Stimulation (tDCS) and transcranial Alternating Current Stimulation (tACS), have emerged as powerful tools for modulating brain activity for both therapeutic and experimental purposes. These methods utilize low-intensity electrical currents to influence cortical excitability, either directly through changes in neuronal membrane polarization or indirectly by affecting broader network dynamics (Thair, 2017). The fundamental mechanisms of stimulation are contingent upon several critical factors, including electrode placement, neuronal orientation relative to the electric field, neuronal morphology, and the spatial distribution of the generated electric field.The effects of non-invasive brain stimulation extend beyond localized brain regions, engaging interconnected neural networks to influence downstream activity. For example, stimulation of the prefrontal cortex has been shown to modulate dopamine release in the striatum, illustrating systemic interactions between the stimulated region and subcortical circuits. Understanding these effects requires a detailed analysis of the technical and physiological aspects that determine the brain's response to stimulation. Electrode distance significantly influences the distribution of the electric field generated during stimulation. Electrodes placed close together produce a more concentrated and intense field in the target area. This focused approach enhances the effectiveness of stimulation for specific purposes, such as targeting the motor cortex in stroke rehabilitation. However, a highly concentrated field also increases the likelihood of localized side effects, such as skin irritation or discomfort.

Conversely, a greater distance between electrodes results in a broader electric field with reduced intensity at the target site. This configuration is ideal for treating conditions like depression or anxiety, where stimulation needs to engage larger and more complex neural networks. Electrode distance also impacts the pathway of current flow through brain tissues, including the cortex, cerebrospinal fluid (CSF), and skull. Variations in tissue conductivity further affect the actual electric field distribution, which often diverges from theoretical models. For example, in computational models, a 5 cm electrode spacing may localize the current to specific gyri, while a 10 cm spacing may activate additional cortical areas or even deeper structures such as the basal ganglia. These nuances are critical in optimizing electrode placement to achieve desired therapeutic outcomes while minimizing unwanted effects. Evidence from relevant animal models indicates that brain injury by Direct Current Stimulation (DCS) occurs at predicted brain current densities (6.3-13 A/m(2)) that are over an order of magnitude above those produced by conventional tDCS. To date, the use of conventional tDCS protocols in human trials (≤40 min, ≤4 milliamperes, ≤7.2 Coulombs) has not produced any reports of a Serious Adverse Effect or irreversible injury across over 33,200 sessions and 1000 subjects with repeated sessions (Bikson et al., 2016).

From Anandam (2009), researchers have made significant progress in recent years, highlighting changes in resting membrane potential, spontaneous neuronal firing rates, synaptic strength, cerebral blood flow and metabolism subsequent to tDCS. From the same research, the orientation of neurons relative to the electric field is a key determinant of stimulation efficacy. Pyramidal neurons, which dominate the cerebral cortex, have dendrites oriented perpendicularly to the cortical surface. Electric fields aligned with this dendritic orientation are most effective in inducing membrane polarization changes, which either enhance excitability (depolarization) or suppress it (hyperpolarization). In tDCS, anodic stimulation typically increases neuronal excitability by depolarizing the membrane, while cathodal stimulation decreases it through hyperpolarization. This principle underlies the application of anodic tDCS in enhancing cognitive functions, such as memory and attention, and cathodal tDCS in suppressing excessive neural activity, as observed in epilepsy. The direction of ionic displacement induced by the electric field also determines synaptic activity levels in the target area. When the field opposes the orientation of dendrites, the neuronal response diminishes, even with higher current intensities. This interplay between neuronal orientation and electric field directionality highlights the importance of personalized stimulation protocols tailored to individual brain anatomies.

Neuronal morphology, particularly the length and branching complexity of dendrites, significantly impacts the responsiveness to electric fields. Pyramidal neurons, with their long and extensively branched dendrites, are more capable of integrating electrical currents compared to neurons with simpler morphologies, such as interneurons. This structural advantage allows pyramidal neurons to serve as primary targets for stimulation in many cortical regions. For example, in the motor cortex, pyramidal neurons directly contribute to motor output, making them ideal targets for rehabilitation in conditions like stroke or spinal cord injuries. In contrast, neurons with shorter dendritic branches may require higher current intensities to elicit comparable responses. Variability in neuronal morphology across different cortical areas also affects how stimulation protocols are designed for specific clinical conditions. Moreover, the intracellular resistance of neurons with complex morphologies can amplify the effects of stimulation. This phenomenon may explain why tDCS and tACS protocols targeting areas with high dendritic density often produce more pronounced behavioral and physiological changes compared to regions with simpler neural architectures (Das et al., 2016).

From Das et al., (2016), non-invasive brain stimulation exerts profound effects on neurotransmission, particularly involving the glutamatergic and GABAergic systems. Anodal tDCS, which increases neuronal excitability, is often associated with enhanced glutamate release, facilitating synaptic activity and promoting long-term synaptic plasticity mechanisms such as long-term potentiation (LTP). Conversely, cathodal tDCS enhances GABAergic activity, suppressing excessive neural firing and supporting inhibitory processes. In addition to classical neurotransmitters, brain stimulation also modulates neuromodulators such as dopamine, serotonin, and norepinephrine. Dopamine, a key player in motivation and reward processing, is heavily influenced by stimulation of the prefrontal cortex. Studies have demonstrated that prefrontal stimulation enhances dopamine release in the striatum, providing a neurobiological basis for its use in treating depression and attention disorders. Serotonin and norepinephrine also play critical roles in regulating mood and arousal, making them relevant targets for anxiety and post-traumatic stress disorder (PTSD) interventions. Furthermore, non-invasive stimulation can affect the expression and trafficking of receptor proteins, such as NMDA and AMPA receptors, in post-synaptic neurons. These changes contribute to the consolidation of stimulation effects, extending their therapeutic benefits beyond the immediate duration of application. Neural oscillations, or rhythmic patterns of brain activity, are fundamental to cognitive and motor functions. Different frequency bands, such as alpha (8–12 Hz), beta (13–30 Hz), and gamma (30–80 Hz), govern distinct neural processes. tACS allows for selective modulation of these oscillatory frequencies, offering a precise approach to altering brain activity. For instance, enhancing alpha oscillations has been shown to improve relaxation and reduce symptoms of insomnia, while boosting beta oscillations may aid in alleviating motor symptoms in Parkinson's disease. Conversely, tACS can also desynchronize neural activity at specific frequencies, which is particularly useful in conditions like epilepsy, where hyper-synchronized neural firing underlies the pathology. The ability of tACS to entrain or disrupt oscillatory activity provides new avenues for treating disorders involving dysregulated brain rhythms, such as schizophrenia and ADHD. This capability to modulate oscillations also holds promise for enhancing cognitive functions, including working memory and decision-making.

The effects of stimulation often extend to brain regions far beyond the direct target area, owing to the brain's intricate synaptic connectivity. Stimulation not only modulates local neuronal populations but also influences broader neural networks. For example, stimulating the dorsolateral prefrontal cortex (DLPFC) can impact subcortical structures like the amygdala and hippocampus, which are involved in emotion regulation and memory processing. The spatial extent of stimulation effects depends on the electrode montage design. Smaller electrodes with closer spacing are effective for targeting specific cortical regions with high precision, while larger electrodes placed further apart are better suited for modulating distributed networks (Lefaucher, 2017). However, wider spatial distribution increases the risk of activating non-target areas, potentially leading to unintended side effects. Advances in computational modeling and neuroimaging have enabled more accurate predictions of electric field distribution, facilitating the development of personalized stimulation protocols. Techniques such as finite element modeling and MRI-based current flow simulations provide insights into how different electrode configurations affect field intensity and coverage (Arul-Anandam & Loo, 2009). The growing understanding of the mechanisms underlying non-invasive brain stimulation has opened new possibilities for treating a wide range of neurological and psychiatric disorders. For instance, tDCS is increasingly used in post-stroke rehabilitation to enhance motor recovery, while tACS is being explored for its potential to alleviate symptoms of epilepsy and

Parkinson's disease. Beyond clinical applications, these techniques also hold promise for cognitive enhancement in healthy individuals. Studies have shown that targeted stimulation can improve learning, memory, and problem-solving skills, raising ethical questions about their use in non-clinical settings. Future research should focus on optimizing stimulation parameters, such as current intensity, electrode placement, and stimulation duration, to maximize efficacy and minimize risks. Combining brain stimulation with other interventions, such as pharmacological treatments or behavioral therapies, may further enhance its therapeutic potential (Das et. al., 2016).

Binaural beat stimulation has garnered significant attention in studies focusing on brain functions, emotional regulation, and mental well-being. This mechanism works by introducing two tones of slightly different frequencies to each ear, creating the illusion of a third tone called the beat frequency, which resonates in the brain. This resonance is believed to influence brainwave activity, which is closely linked to various cognitive functions, mood, and emotions (Colzato et al., 2017). As a non-invasive method, binaural beats offer a promising avenue for exploration in psychological and neurological therapy. The effects of this stimulation vary depending on the frequency of the beats used. Low frequencies, such as delta (0–4 Hz), are associated with deep relaxation and sleep, while higher frequencies, such as beta (16–24 Hz) and gamma (>30 Hz), are linked to heightened focus, alertness, and more complex information processing. However, its potential benefits are not uniform, as the effects depend on the duration of stimulation, specific frequencies, and even individual characteristics, such as dopamine levels and personality traits (Mirmohadi et al., 2024).

Chaeib et al. (2015) dan Ingendoh et al. (2023) studied memory and binaural beats. Theta frequencies (4–8 Hz) are often linked to memory processes, including both short-term and long-term memory. However, research results have been mixed. For instance, a study by Wahbeh et al. reported that theta stimulation at 7 Hz for 30 minutes reduced immediate verbal memory performance as assessed by the Rey Auditory Verbal Learning Test (RAVLT). This finding is surprising, given that theta frequencies are often associated with memory consolidation in neuroscience literature. Conversely, other studies have shown that similar frequencies, when applied over a 15-day period, significantly improved verbal memory, as measured by the Wechsler Memory Scale III (Kim et al., 2024). These inconsistencies highlight the importance of stimulation duration and patterns.

Short-term stimulation may not allow the brain sufficient time to adapt to new patterns of electrical activity induced by binaural beats. In contrast, long-term stimulation appears to facilitate the strengthening of synaptic connections that support memory processes. This aligns with the theory of neuroplasticity, which posits that repeated exposure to specific stimuli can trigger structural changes in the brain. Creativity is often measured by one’s ability to generate new ideas (divergent thinking) and find single solutions to complex problems (convergent thinking). Binaural beat stimulation, particularly at alpha (10 Hz) and gamma (40 Hz) frequencies, has been shown to enhance divergent thinking abilities. For example, the Alternate Uses Task (AUT), which evaluates creativity by assessing the ability to identify alternative uses for everyday objects, showed improved performance following stimulation with these frequencies. Additionally, research indicates that the effectiveness of binaural beats in boosting creativity may be influenced by dopamine levels, as indicated by Eye Blink Rate (EBR). Individuals with low EBR, signifying lower baseline dopamine levels, tend to benefit more from alpha frequency stimulation. This suggests a complex interplay between neural activity induced by binaural beats and the brain’s neurochemical mechanisms. However, studies on creativity also highlight the limitations of binaural beat usage. Certain frequencies appear more effective for specific creative tasks but not others. For instance, while gamma frequencies enhance performance on the Remote Associations Task (RAT)—a measure of the ability to identify hidden relationships between words—these frequencies do not significantly impact convergent thinking (Rakhshan et.al, 2022) .

From Engelbregt et al. (2019), the present study supports the notion that faster attention processing may equally be attributed to the influence of binaural beat. One potential application of binaural beats is in managing attention disorders, such as Attention Deficit Hyperactivity Disorder (ADHD). Early research suggests that stimulation with beta frequencies (16–24 Hz), associated with alertness, can help improve focus in children and adolescents with ADHD. Although quantitative results from assessments like the Test of Variables of Attention (TOVA) did not show significant improvements, subjective reports from participants indicated reduced symptoms of inattention. This research provides hope but also underscores the need for further exploration. Stimulation duration, task type, and the severity of ADHD are variables that may influence outcomes but remain poorly understood. Moreover, longitudinal studies measuring the long-term effects of binaural beat stimulation on attention are still scarce. The impact of binaural beat stimulation on anxiety is one area with consistent findings. Delta frequencies (0–4 Hz) have been shown to effectively reduce situational anxiety, such as that experienced by pre-operative patients. In one study, 30 minutes of stimulation reduced anxiety levels by 26.3%, compared to 11.1% in the placebo group, as measured by the State-Trait Anxiety Inventory (STA-I). Additionally, daily stimulation over a longer duration has demonstrated significant reductions in chronic anxiety (trait anxiety). This indicates that binaural beats are not only effective in alleviating short-term anxiety but also hold potential as a long-term therapy for more serious anxiety disorders (Garcia et al., 2019).

From the same study, mood modulation is another area where binaural beat stimulation shows promise. Delta frequencies not only reduce anxiety but also alleviate tension and confusion, as measured by the Profile of Mood States (POMS). Conversely, beta frequencies appear to enhance positive moods, particularly in contexts requiring high alertness. However, understanding the effects of binaural beats on mood poses challenges. For instance, some studies suggest that certain frequencies may inconsistently influence emotions, such as exacerbating depression on some scales while reducing anxiety.

Factors such as individual sensitivity to auditory stimuli and psychological context during stimulation may affect these outcomes (Chaieb, 2015). For tasks requiring sustained attention, such as air traffic control or industrial process monitoring, binaural beat stimulation at beta frequencies has shown promising results. Research suggests that individuals stimulated with these frequencies are better able to maintain focus compared to control groups (Sudre, 2024). Additionally, personality dimensions like Openness and Conscientiousness appear to influence responsiveness to stimulation.

People scoring high in these traits are more likely to benefit from beta stimulation, indicating an interaction between individual characteristics and binaural beat efficacy. The data collected is processed in real-time by a microprocessor within the headphones, then transferred to a smartphone via Bluetooth, allowing users to access information through the EmoTrack app. This smart application is part of telemedicine based on the Internet of Things and powered by artificial intelligence (AI), accessible free of charge to all users (Chaeib *et. al,* 2016).

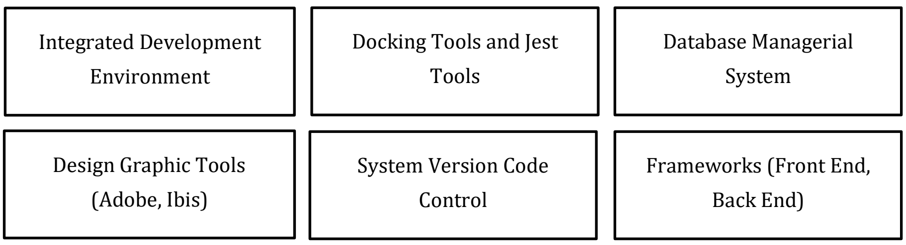

Fig. 3. Software components of the emotrack app

In the era of digital health, technology has approached mental well-being, offering new tools for emotional regulation, addiction recovery, and personal growth. A mental health app designed with an integrative approach provides a host of features to meet diverse user needs (Figure 4). These features not only address therapeutic goals but also create a supportive, engaging, and stigma-free environment for users navigating emotional or psychological challenges.

One cornerstone of the app is its community feature, which connects users with various support networks, events, and interactive activities. These communities foster solidarity and mutual understanding among individuals with shared experiences. Whether through virtual events, discussion forums, or offline gatherings, users can find safe spaces to share stories, seek advice, and build camaraderie. For instance, the app might host weekly webinars with mental health professionals or peer-led support sessions for addiction recovery. By encouraging participation, the community feature helps reduce feelings of isolation, which often exacerbate mental health challenges. Studies suggest that individuals who engage in community-based activities report greater emotional resilience and improved recovery outcomes. This sense of belonging is especially crucial in cultures where discussing mental health remains taboo.

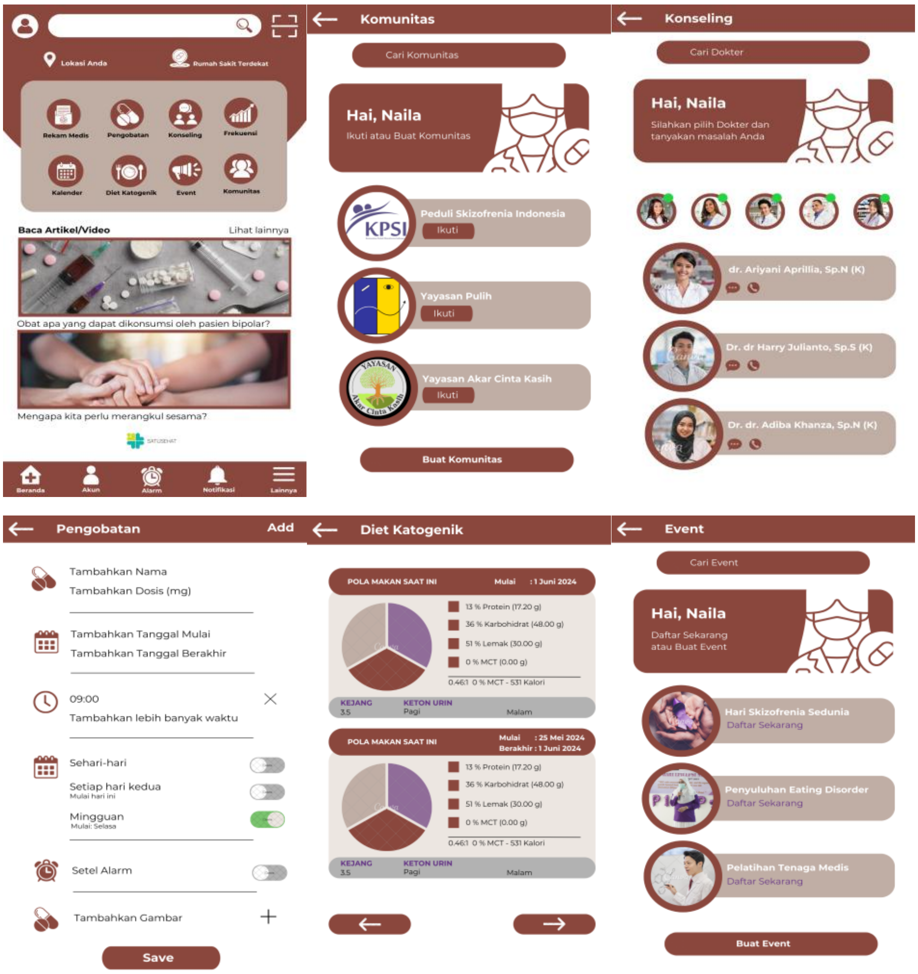

Fig. 4. EmoTrack app display

The Space feature adds a unique, social media-inspired dimension to the app. Users can anonymously share their progress in psychotherapy or emotional regulation, post updates on personal achievements, and connect with others facing similar struggles. Designed with privacy as a priority, this feature protects users' identities and medical records while enabling them to share openly. For example, a user recovering from addiction can document their journey by posting updates on relapse frequency, emotional triggers, and coping mechanisms. These posts can spark encouragement from others in the community, fostering a sense of accountability and collective growth. Moreover, users can participate in positive growth challenges, such as achieving a milestone of one month addiction-free or completing a week of daily meditation. Participants earn rewards, such as virtual badges or redeemable points, which provide additional motivation. These gamified elements are designed to reinforce behavioral change while making the process enjoyable. By celebrating small victories, the Space feature empowers users to stay committed to their goals.

Understanding and managing emotions is at the core of mental wellness. The Mood Tracker offers users a way to monitor their emotional fluctuations throughout the day. With a simple interface, users can log their feelings, rate their moods, and reflect on possible triggers for emotional changes. The tracker doesn't just collect data; it actively supports users by offering personalized activity recommendations based on their emotional state. For instance, if a user logs feelings of anxiety, the app might suggest a guided breathing exercise or a soothing meditation session. Alternatively, if a user feels unmotivated, the app could recommend an energizing playlist or a goal-setting exercise. Over time, the tracker generates trends and insights, enabling users to identify patterns and triggers in their emotional landscape.

The app's Guided Meditation feature offers a range of sessions tailored to diverse emotional needs, from reducing stress and enhancing focus to cultivating gratitude and fostering sleep. Users can choose sessions based on their mood or long-term goals. For example, a user preparing for a challenging day at work might select a quick, five-minute meditation to boost confidence, while someone struggling with insomnia might opt for a 20-minute sleep-focused meditation. By integrating soothing audio, calming visuals, and mindfulness techniques, the meditation feature helps users ground themselves in the present moment. Scientific studies consistently highlight the benefits of mindfulness meditation in reducing stress, improving concentration, and fostering emotional regulation.

Emotional regulation often requires learning healthy ways to release pent-up emotions. The Emotional Release Exercises (ERE) feature equips users with tools to process emotions constructively. Using guided breathing exercises, visualization, and relaxation techniques, the ERE feature teaches users to address emotional distress without resorting to harmful coping mechanisms, such as substance abuse or aggression. For example, a user feeling overwhelmed might follow a step-by-step breathing guide to calm their nervous system. Alternatively, visualization exercises might involve imagining a peaceful scene while letting go of negative thoughts. The ERE feature also introduces grounding techniques, such as focusing on sensory details to redirect attention away from distress. Beyond self-help, the ERE feature links users to the Counseling feature, where they can interact with AI or professionals. For instance, if a user finds it difficult to manage recurring anxiety, the app's AI counselor might offer conversational support and suggest next steps, such as scheduling an appointment with a psychologist.

The Counseling feature bridges the gap between users and mental health professionals. Through this feature, users can schedule consultations with doctors, psychologists, or pharmacists, both in-person and online. This flexibility ensures that help is accessible regardless of a user's location or time constraints. Additionally, the app's AI-based counseling tool provides immediate, preliminary support for emotional issues. While AI cannot replace professional therapy, it can serve as a valuable first step, offering coping strategies, answering common questions, or guiding users toward appropriate resources.

For users undergoing pharmacological treatment, the Medication Management feature is indispensable. This feature tracks medication schedules, sends reminders, and monitors adherence. For instance, a user taking antidepressants might receive daily notifications to take their dose and log their adherence. Doctors can access detailed reports through the app, allowing them to assess treatment effectiveness and address any issues, such as side effects or non-compliance. By streamlining medication management, the app supports users in maintaining consistent treatment regimens, which is critical for positive outcomes.

Tracking progress is essential for motivation and self-awareness. The app's Trends and Calendar features allow users to monitor their emotional and behavioral patterns over time. For example, users can visualize trends in relapse frequency, mood fluctuations, or meditation consistency through intuitive graphs and charts. These insights empower users to identify correlations, such as how dietary changes or sleep patterns influence their mood. With a clear picture of their progress, users can make informed adjustments to their routines and celebrate milestones along the way.

Recognizing the profound link between nutrition and mental health, the app includes a Diet feature offering dietary guidance and meal plans tailored to emotional well-being. For instance, the app might suggest serotonin-boosting foods, such as bananas or dark chocolate, to combat low moods. Users can log their meals, track nutritional intake, and receive tips on maintaining a balanced diet. Research underscores the role of nutrition in regulating mood and cognitive function. Omega-3 fatty acids, for example, are associated with reduced symptoms of depression, while a diet rich in antioxidants can mitigate oxidative stress linked to anxiety. By promoting healthy eating habits, the app complements its other features to create a holistic wellness experience.

An informed user is an empowered user. The app's Education feature provides a wealth of resources, including articles, videos, and infographics on topics like emotional regulation, mental health disorders, and self-care strategies. By offering accessible, evidence-based content, this feature aims to reduce stigma and encourage users to seek help when needed. For example, a user hesitant to consult a psychologist might watch a video debunking common myths about therapy. Similarly, articles on the dangers of untreated mental health issues can motivate proactive care. By fostering understanding, the Education feature helps break down barriers to mental health support.

To streamline health information management, the app integrates with Indonesia's "Satu Sehat" platform. This collaboration enables seamless data sharing between users and healthcare providers, enhancing continuity of care. For instance, a user's medication adherence data or therapy progress can be directly accessed by their doctor, ensuring coordinated treatment. This app represents a comprehensive solution for mental health management, combining advanced technology with user-centric design. From fostering community connections and providing professional counseling to tracking mood and diet, its features address the multifaceted nature of mental well-being. By empowering users to take charge of their emotional health, this app not only alleviates individual struggles but also contributes to a more supportive and stigma-free society.

3.2 SWOT analyze and cost analyze

The SWOT analysis conducted relates to the innovation of tDCS and binaural beat-based devices. The innovation aims to address sexual deviation in Indonesia by identifying strengths, weaknesses, opportunities, and threats that may affect its development. The following are the results of the SWOT analysis in table 1.

Table 1. SWOT Analyze

No	Strength
1	A unique innovation that combines tDCS and binaural beat technology to address sexual deviance, a solution not yet widely implemented in Indonesia.
2	A therapeutic alternative that does not require medications or invasive medical procedures, making it safer to use.
3	The device offers numerous advantages in helping to address often overlooked sexual deviance issues, supporting improvements in community mental health.
4	Indonesia has a large population with significant issues related to sexual deviance, creating a broad potential market
5	Comfortable and easy-to-use design, app-based, and wearable, allowing users to access therapy independently.
No	Weaknesses
1	tDCS and binaural beat technology may require costly components. However, partnerships with the stakeholders mentioned could make the product more affordable for the community.
2	Lack of public education about sexual deviance and the benefits of tDCS among the general public may hinder product acceptance. This can be addressed through integration with Satu Sehat and direct outreach by the Ministry of Health.
3	Device performance is highly dependent on complex technology, making it vulnerable to technical issues and requiring good maintenance.

No	Opportunites
1	Growing awareness of the importance of mental health in Indonesia opens opportunities for this innovation to gain broader attention.
2	The Indonesian government and non-governmental organizations (NGOs) are increasingly active in supporting initiatives to combat sexual deviance, providing opportunities for collaboration to enhance market penetration.
3	Advances in wearable and digital technology present opportunities to improve product quality and reduce production costs.

No	Threats
1	Strict regulations regarding health devices and technology in Indonesia can pose obstacles in the certification and distribution process. Therefore, government support for device and application certification is essential..
2	Low levels of awareness or education regarding sexual deviance may slow the adoption of this tool in the broader market. Consequently, education and outreach from the Ministry of Health and NGOs are necessary.

Furthermore, the results of the cost analysis related to software and hardware will be described. Table 2 displays the software cost analysis that includes various important components such as IDEs, cloud-based databases, hosting services, and development and design tools. The following are the results of Table 2 as follows.

Table 2. Software Cost Analyze

No	Software Component	Costs (IDR/year)
1	IDE (JetBrains IntelliJ)	2,309,500
2	Docker Pro	930,000/1 user
3	Cloud-based database	2,790,000
4	Adobe Creative Cloud	9,845,340
5	GitHub Team	744,000/1 user
6	Hosting/server	930,000
Total		2,003,000 - Rp4,060,000

In addition, Table 3 details the estimated cost of the hardware required for the development of the system. The presentation of Table 3 includes major components such as the microcontroller, tDCS sensor, GPS module, and signal amplifier. The following are the results of the price range exposure, though it varies quite a bit.

Table 3. Hardware Cost Analyze

No	Hardware Component	Costs (IDR/year)
1	IDE (JetBrains IntelliJ)	80,000 – 100,000
2	Docker Pro	5,000 – 15,000
3	Cloud-based database	20,000 – 50,000
4	Adobe Creative Cloud	2,000 – 10,000
5	GitHub Team	1,000 – 5,000
6	Hosting/server	30,000 – 80,000
7	tDCS Sensor	1,500,000 – 3,000,000
8	GPS Module	100,000 – 150,000
9	Breadboard	15,000 – 50,000
10	Binaural Beater	200,000 – 500,000
11	Signal Amplifier	50,000 – 100,000

3.5 Realization of EmoTrack

In developing EmoTrack, it is essential to involve the younger generation, the Ministry of Health, BPJS (Indonesian Health Insurance), relevant non-governmental organizations, and research and educational institutions. Although the main target is the general public, the younger generation plays a crucial role as the starting point for national enlightenment and human resource quality, which is the primary target of EmoTrack. Youth contributions are needed in socialization, research, development, and facility support. Collaboration with the Ministry of Health and BPJS facilitates EmoTrack in design realization, licensing, integration with Satu Sehat, and financial guarantees that can ease the burden on patients requiring regular monitoring. Other institutions can assist in developing and refining technology and outreach, as well as providing platforms for youth involvement.

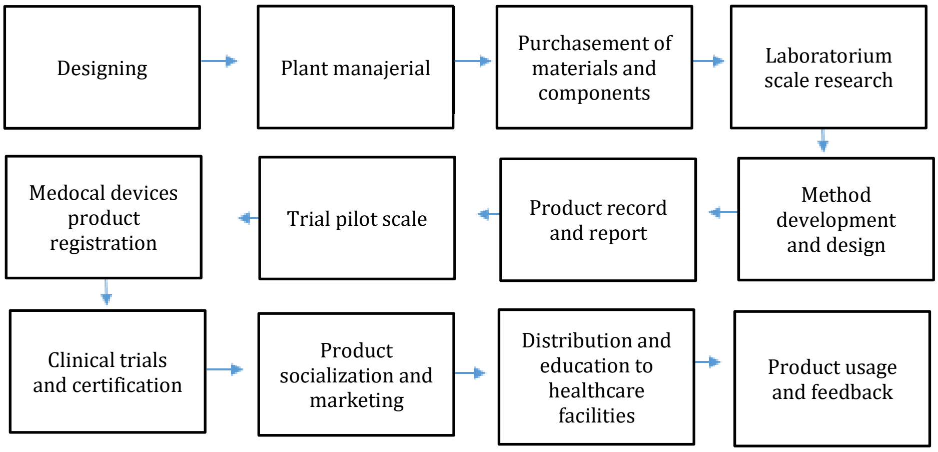

Fig. 5. EmoTrack app display

EmoTrack's actualization offers numerous benefits, especially in enhancing mental health and productivity. With tDCS and binaural beat technology, this device can help individuals control compulsive urges, improve self-control, and support non-invasive rehabilitation. This technology also enables people to manage their emotions, thereby improving individual quality of life and playing a significant role in daily life and social relationships. This innovation not only contributes to reducing the prevalence of mental health issues but also fosters a healthier generation, both mentally, emotionally, and physically. In the context of Indonesia Emas 2045, EmoTrack can support the first pillar of the vision of Indonesia Emas through achieving a superior, productive, and globally competitive human resource base, where healthy societal behavior forms the foundation of sustainable national development. EmoTrack indirectly supports various 2030 SDG targets. EmoTrack addresses Goal 3 and 4, which concern health, well-being, and quality education, as managing emotional issues can improve mental health, well-being, and productivity. Increased productivity through EmoTrack can also stimulate economic growth (Goal 8) and promote innovation and industry (Goal 9). A more peaceful and resilient society (Goal 16) can also be achieved through the reduction of mental health issues that may lead to compulsive behaviors contributing to social problems.

4. Conclusions

The electronic system of a modern, telemedicine-integrated headset application provides a solution to combat emotional and mental disorders stemming from technology misuse in Indonesia. EmoTrack monitors the recurrence of mental health disorders, improves knowledge and reduces stigma, and integrates with Ministry of Health and NGO programs, thus expanding the reach of services in terms of mobility and economy. With support from the younger generation, EmoTrack has the potential to contribute to the Indonesia Emas 2045 vision through advancements in human development, science, and technology, while also supporting the realization of the 2030 SDGs. Therefore, the author strongly recommends the implementation of EmoTrack, which holds great potential to foster healthy digitalization in the era of modernization and Society 5.0.

Acknowledgement

The author wishes to acknowledge the contributions of colleagues and mentors from the Kementerian Kesehatan RI who provided invaluable assistance with data collection, interpretation, and manuscript preparation. The author would like to acknowledge the Student Association of Public Health Study Program, Universitas Islam Negeri Syarif Hidayatullah, Jakarta, for their instrumental role in organizing the Essay Competition 2024.

Author Contribution

Each author is expected to make substantial contributions to the organizational design or designs; or to the acquisition, analysis, or interpretation of data; or to the creation of new software used in the work; or to the drafting or substantive revision of the work; and to the approval of the submitted version (and any substantially modified versions by journal staff, which includes the author's contributions to the work).

Funding

This research received no external funding.

Ethical Review Board Statement

Not available.

Informed Consent Statement

Not available.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Conflicts of Interest

The authors declare no conflict of interest.

Open Access

References

Arul-Anandam, A. P., & Loo, C. (2009). Transcranial direct current stimulation: a new tool for the treatment of depression?. *Journal of affective disorders, 117*(3), 137–145. https://doi.org/10.1016/j.jad.2009.01.016

Baseanu, I. C. C., Roman, N. A., Minzatanu, D., Manaila, A., Tuchel, V. I., Basalic, E. B., & Miclaus, R. S. (2024). The Efficiency of Binaural Beats on Anxiety and Depression—A Systematic Review. *Applied Sciences, 14*(13), 5675. https://www.mdpi.com/2850398

Bennabi, D., & Haffen, E. (2018). Transcranial Direct Current Stimulation (tDCS): A Promising Treatment for Major Depressive Disorder? *Brain sciences*, *8*(5), 81. https://doi.org/10.3390/brainsci8050081

Bikson, M., Grossman, P., Thomas, C., Zannou, A. L., Jiang, J., Adnan, T., Mourdoukoutas, A. P., Kronberg, G., Truong, D., Boggio, P., Brunoni, A. R., Charvet, L., Fregni, F., Fritsch, B., Gillick, B., Hamilton, R. H., Hampstead, B. M., Jankord, R., Kirton, A., Knotkova, H., ...

Woods, A. J. (2016). *Brain stimulation*, *9*(5), 641–661. https://doi.org/10.1016/j.brs.2016.06.004

Chaieb, L., Wilpert, E. C., Reber, T. P., & Fell, J. (2015). Auditory beat stimulation and its effects on cognition and mood States. *Frontiers in psychiatry*, *6*, 70. https://doi.org/10.3389/fpsyt.2015.00070

Cheng, P. W. C., Louie, L. L. C., Wong, Y. L., Wong, S. M. C., Leung, W. Y., Nitsche, M. A., & Chan, W. C. (2020). The effects of transcranial direct current stimulation (tDCS) on clinical symptoms in schizophrenia: A systematic review and meta-analysis. *Asian journal of psychiatry*, *53*, 102392. https://doi.org/10.1016/j.ajp.2020.102392

Colzato, L. S., Barone, H., Sellaro, R., & Hommel, B. (2017). More attentional focusing through binaural beats: evidence from the global-local task. *Psychological research*, *81*(1), 271–277. https://doi.org/10.1007/s00426-015-0727-0

Das, S., Holland, P., Frens, M. A., & Donchin, O. (2016). Impact of Transcranial Direct Current Stimulation (tDCS) on Neuronal Functions. *Frontiers in neuroscience*, *10*, 550. https://doi.org/10.3389/fnins.2016.00550

Dewanto, G., Suwono, W. J., Riyanto, B., Turana, Y., & Suryana, N. (2009). *Panduan Praktis Diagnosis dan Tatalaksana Penyakit Saraf*. Penerbit Buku Kedokteran EGC.

D'Urso, G., Toscano, E., Barone, A., Palermo, M., Dell'Osso, B., Di Lorenzo, G., ... & de Bartolomeis, A. (2023). Transcranial direct current stimulation for bipolar depression: systematic reviews of clinical evidence and biological underpinnings. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *121*, 110672. https://doi.org/10.1016/j.pnpbp.2022.110672

Febriandi, S., & Rahmi, S. A. (2023). Evaluasi Posbindu Dalam Mencegah Penyakit Tidak Menular. *Jurnal Ilmu Kesehatan Mulia Madani Yogyakarta*, *4*(2), 1-10. https://jurnal.lppm-mmy.ac.id/index.php/jik

Garcia-Argibay, M., Santed, M. A., & Reales, J. M. (2019). Efficacy of binaural auditory beats in cognition, anxiety, and pain perception: a meta-analysis. *Psychological research, 83*(2), 357–372. https://doi.org/10.1007/s00426-018-1066-8

Ingendoh, R. M., Posny, E. S., & Heine, A. (2023). Binaural beats to entrain the brain? A systematic review of the effects of binaural beat stimulation on brain oscillatory activity, and the implications for psychological research and intervention. *PloS one*, *18*(5), e0286023. https://doi.org/10.1371/journal.pone.0286023

Jog, M. A., Anderson, C., Kubicki, A., Boucher, M., Leaver, A., Hellemann, G., Iacoboni, M., Woods, R., & Narr, K. (2023). Transcranial direct current stimulation (tDCS) in depression induces structural plasticity. *Scientific reports*, *13*(1), 2841. https://doi.org/10.1038/s41598-023-29792-6

Kemenkes RI [Kementerian Kesehatan Republik Indonesia/Ministry of Health of the Republic of Indonesia]. (2021). *Kemenkes Beberkan Masalah Permasalahan Kesehatan Jiwa di Indonesia*. Kementerian Kesehatan RI. https://sehatnegeriku.kemkes.go.id/baca/rilis-media/20211007/1338675/kemenkes-beberkan-masalah-permasalahan-kesehatan-jiwa-di-indonesia/

Kim, J., Kim, H. W., Kovar, J., & Lee, Y. S. (2024). Neural consequences of binaural beat stimulation on auditory sentence comprehension: an EEG study. *Cerebral cortex*, *34*(1), bhad459. https://doi.org/10.1093/cercor/bhad459

Lefaucheur, J. P., Antal, A., Ayache, S. S., Benninger, D. H., Brunelin, J., Cogiamanian, F., Cotelli, M., De Ridder, D., Ferrucci, R., Langguth, B., Marangolo, P., Mylius, V., Nitsche, M. A., Padberg, F., Palm, U., Poulet, E., Priori, A., Rossi, S., Schecklmann, M., Vanneste, S. Paulus, W. (2017). Evidence-based guidelines on the therapeutic use of transcranial direct current stimulation (tDCS). *Clinical neurophysiology: Official journal of the International Federation of Clinical Neurophysiology*, *128*(1), 56–92. https://doi.org/10.1016/j.clinph.2016.10.087

Mirmohamadi, S., Norozpour, Y., & Zarrabian, S. (2024). A Review of Binaural Bates and the Brain. *Basic and clinical neuroscience*, *15*(2), 133–146. https://doi.org/10.32598/bcn.2022.1406.2

Pringgoutami, Z., & Perdani, R. R. W. (2017). Efek Binaural Beats terhadap Attention Deficit Hyperactivity Disorder (ADHD). *Jurnal Majority*, *7*(1), 106-111. http://repository.lppm.unila.ac.id/id/eprint/8936

Rakhshan, V., Hassani-Abharian, P., Joghataei, M., Nasehi, M., & Khosrowabadi, R. (2022). Effects of the Alpha, Beta, and Gamma Binaural Beat Brain Stimulation and Short-Term Training on Simultaneously Assessed Visuospatial and Verbal Working Memories, Signal Detection Measures, Response Times, and Intrasubject Response Time Variabilities: A Within-Subject Randomized Placebo-Controlled Clinical Trial. *BioMed research international*, 2022, 8588272. https://doi.org/10.1155/2022/8588272

Roser, M., Ritchie, H., & Spooner, F. (2024). *Burden of disease: How is the burden of disease distributed and how did it change over time?* Our World in Data. https://ourworldindata.org/burden-of-disease

Shalforoushan, S. M., & Golmakani, Z. B. (2023). Effects of Combined Binaural Beats on Sleep Quality, Insomnia Severity, and Sleep Hygiene Improvement in Insomniac Students. *Journal of Sleep sciences*, *17*(1-2). https://publish.kne-publishing.com/index.php/JSS/article/view/13212

Stagg, C. J., Antal, A., & Nitsche, M. A. (2018). Physiology of Transcranial Direct Current Stimulation. *The journal of ECT*, *34*(3), 144–152. https://doi.org/10.1097/YCT.0000000000000510

Stein, D. J., Fernandes Medeiros, L., Caumo, W., & Torres, I. L. (2020). Transcranial Direct Current Stimulation in Patients with Anxiety: Current Perspectives. *Neuropsychiatric disease and treatment*, *16*, 161–169. https://doi.org/10.2147/NDT.S195840

Sudre, S., Kronland-Martinet, R., Petit, L., Rozé, J., Ystad, S., & Aramaki, M. (2024). A new perspective on binaural beats: Investigating the effects of spatially moving sounds on human mental states. *PloS one*, *19*(7), e0306427. https://doi.org/10.1371/journal.pone.0306427

Thair, H., Holloway, A. L., Newport, R., & Smith, A. D. (2017). Transcranial Direct Current Stimulation (tDCS): A Beginner's Guide for Design and Implementation. *Frontiers in neuroscience, 11,* 641. https://doi.org/10.3389/fnins.2017.00641

Biographies of Author

Siti Naila Nafisya, is a student at UIN Syarif Hidayatullah, located in Jakarta. Her academic background is in the field of pharmacy, with a research focus on microbiology, drugs, and health technologies.

- Email: sitinaila2004@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A