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Lifestyle and the Gut-Brain Axis Insights into Mental Health and Microbiome Interactions

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Abstract:-

➢ ***Introduction:***

The intricate relationship between lifestyle factors and gut health has become a focus of recent research, emphasizing the significant role of the gut-brain axis (GBA) in regulating both physical and emotional well-being. Unhealthy lifestyle choices, including a diet high in ultra-processed foods, irregular sleep patterns, physical inactivity, and substance abuse, have been closely associated with gut dysbiosis, leading to gastrointestinal (GI) symptoms and mood disturbances such as anxiety and depression. The gut microbiota, through the production of neurotransmitters like serotonin and dopamine, as well as short-chain fatty acids (SCFAs), influences mood and mental health via the GBA. Maintaining a healthy lifestyle, characterized by balanced nutrition, regular physical activity, and good sleep quality, is critical in fostering a diverse and stable gut microbiome, which in turn supports emotional stability.

➢ ***Aim:***

This review aims to examine the existing literature on the impact of lifestyle factors, such as diet, physical activity, sleep, smoking, alcohol consumption, and stress management, on gut health and emotional well-being. The goal is to highlight the importance of gut microbiota in mental health and the potential therapeutic strategies to enhance gut health for improved emotional outcomes.

➢ ***Methodology:***

A comprehensive search of peer-reviewed journal articles was conducted using databases such as PubMed, Google Scholar, and Web of Science. Keywords like "lifestyle," "gut health," "emotional well-being," "dietary habits," "physical activity," "sleep patterns," and "gut-brain axis" were used to identify relevant studies. Inclusion criteria focused on human clinical trials and observational studies published within the last 16 years. Studies involving animal subjects, non-peer-reviewed articles, and outdated research were excluded.

➢ ***Results:***

The literature shows that diets high in fiber and low in processed foods support a healthier gut microbiome, while high consumption of ultra-processed foods disrupts gut bacteria, leading to GI symptoms and mood disorders. Regular physical activity was found to enhance gut microbiota diversity, contributing to better emotional well-being. Conversely, poor sleep quality and chronic stress were linked to gut dysbiosis, which exacerbated mood disturbances. Smoking and excessive alcohol consumption further damaged gut health, contributing to mood dysregulation. Probiotic and prebiotic interventions, particularly synbiotics, were found to restore gut balance and improve both GI and mental health outcomes.

➢ ***Conclusion:***

This review underscores the pivotal role of lifestyle choices in shaping gut health and emotional well-being. A balanced diet, regular exercise, sufficient sleep, and stress management are essential for maintaining a healthy gut microbiome, which, in turn, supports emotional stability. Therapeutic strategies involving prebiotics, probiotics, and synbiotics offer promising avenues for improving both gut health and mood. Addressing lifestyle factors and promoting gut health can potentially serve as an effective approach for enhancing overall well-being and preventing mood disorders.

Keywords:- *Gut-Brain Axis, Gut Health, Lifestyle Factors, Emotional Well-Being, Diet, Physical Activity, Probiotics, Prebiotics.*

I. INTRODUCTION

An individual's lifestyle choices have a profound impact on their overall health and well-being. In recent years, there has been greater interest in a possible link between lifestyle factors and gut health, along with the complementary impact on emotional and mental well-being.

The intricate interplay between lifestyle choices and overall health has garnered significant attention in recent years, particularly in understanding how these factors influence gut health and emotional well-being. A growing body of research suggests that common lifestyle habits—such as excessive consumption of ultra-processed foods, irregular eating patterns, physical inactivity, inadequate sleep, smoking, and alcohol consumption—are closely associated with a range of adverse health outcomes. These behaviours are not only detrimental to physical health but also profoundly impact mental well-being, emphasizing the importance of holistic health management.

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At the heart of this connection lies the gut-brain axis (GBA), a complex bidirectional communication system between the gut microbiome and the central nervous system. The GBA plays a critical role in regulating mood and mental health through neural, hormonal, and immune pathways, underscoring the significant influence that gut health has on emotional states. Disruptions in the gut microbiome, often resulting in gastrointestinal issues such as bloating, constipation, and diarrhoea, have been shown to affect mood, leading to conditions like anxiety and depression. This relationship between gut health and mental well-being is increasingly recognized as a pivotal area of study, especially given the rising prevalence of lifestyle-related diseases and mental health conditions.

Recent research has further illuminated the role of specific gut microbiota in modulating mood and emotional well-being. For instance, alterations in gut microbiota composition have been linked to changes in mood, with certain bacterial species like *Ruminococcus gnavus* being associated with depression metrics (Chahwan et al., 2019). Similarly, dietary interventions, such as prebiotic supplementation with inulin, have demonstrated the ability to enhance mood by positively influencing gut-brain communication pathways, particularly in individuals with specific baseline gut microbiota compositions (Leyrolle et al., 2021). The gut microbiota produces key neurotransmitters like serotonin, dopamine, and gamma-aminobutyric acid (GABA), which are essential for mood regulation and cognitive processes. Additionally, short-chain fatty acids (SCFAs) such as butyrate, produced by gut bacteria, have anti-inflammatory properties and can cross the blood-brain barrier to exert neuroprotective effects. These findings suggest that gut dysbiosis may exacerbate mood disorders through mechanisms involving inflammation and altered neurotransmitter production (Madan et al., 2019).

The GBA also involves the vagus nerve, which provides a direct communication pathway between the gut and the brain. Microbial metabolites can activate vagal pathways, influencing brain activity and mood (Madan et al., 2019). Furthermore, immune cells in the gut communicate with the brain through cytokine signalling, affecting emotional states when dysregulated (Leyrolle et al., 2021). This complex interplay highlights the importance of adopting a holistic approach to mental health that includes maintaining gut health through balanced nutrition, lifestyle modifications, and targeted microbial therapies (Chahwana et al., 2019; Zhao et al., 2024).

As research continues to explore the intricate relationship between the gut and the brain, the potential for innovative treatments for mood disorders becomes increasingly evident, emphasizing the critical role of gut health in maintaining emotional well-being. This review explores the existing literature on how these lifestyle factors impact gut health and emotional well-being, emphasizing the need for further investigation.

- *Dietary Habits and Their Impact on Gut Health*

Diet plays a pivotal role in shaping gut health, influencing the composition and function of the gut microbiota. A diet high in fiber and low in processed foods supports a healthy gut microbiome, which is crucial for overall well-being. For instance, adopting a Green-Mediterranean diet, which emphasizes plant-based foods and reduces meat intake, has been shown to significantly improve gut health markers by enriching the genus Prevotella, associated with high fiber intake (Rinott et al., 2022). These microbial shifts contribute to the diet's positive effects on cardiometabolic health, indicating that such dietary patterns could be a valuable strategy for enhancing gut health.

Similarly, a study exploring the effects of a whole-grain-rich diet found that, although it did not significantly alter gut microbiome composition within an 8-week period, it led to subtle positive impacts on gut microbiota. These included an enrichment of genes involved in fiber metabolism and increased microbial metabolites associated with whole grains, such as alkylresorcinol metabolites and phenolic compounds. Additionally, the diet was linked to a reduction in systemic inflammation markers, like CRP and IL-6, suggesting that even subtle dietary changes can benefit gut health over time (Roager et al., 2019).

Conversely, high consumption of ultra-processed foods (UPFs) has been linked to gut dysbiosis, characterized by an imbalance in gut microbiota composition and is linked with having high GI symptoms and mood disturbances. Research indicates that consuming more than five servings per day of UPFs can alter gut microbiota composition, potentially leading to health problems such as hypertension, obesity, metabolic syndrome, depression, and type 2 diabetes (Cuevas-Sierra et al., 2021). Another study found that a diet high in UPFs was linked to a lower adherence to the Mediterranean Diet and a higher total energy intake, contributing to an abundance of taxa associated with inflammatory gastrointestinal diseases (Atzeni et al., 2022). This suggests that UPF consumption can adversely affect gut health, potentially contributing to various health issues related to gut microbiota imbalance.

The link between UPFs and mental health is also noteworthy. A study within the French NutriNet-Santé cohort found that higher UPF intake was associated with an elevated risk of developing depressive symptoms. Although the study did not directly measure changes in gut microbiota, it suggested that non-nutritional components of UPFs, such as food additives, might influence gut microbiota and, consequently, mental health (Adjibade et al., 2019). These additives can promote inflammation and dysbiosis, potentially disrupting the gut-brain axis and contributing to mental health disorders like depression.

Engaging in healthy lifestyle practices, such as regular exercise and a balanced diet, can significantly improve gut microbiota composition and diversity. A study demonstrated that a lifestyle intervention focusing on a healthy diet and physical activity reduced the prevalence of metabolic syndrome and improved gut microbiota diversity in

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participants. This intervention led to increased populations of beneficial bacteria such as Akkermansia muciniphila and Faecalibacterium prausnitzii, which are associated with improved insulin sensitivity and reduced inflammation (Guevara-Cruz et al., 2019).

Furthermore, a year-long lifestyle intervention with a Mediterranean diet led to greater weight loss and improved gut microbiota in overweight and obese individuals, suggesting that dietary patterns rich in fruits, vegetables, and healthy fats can foster a diverse and healthy gut microbiome, thereby enhancing mood and reducing the risk of depression (García-Gavilán et al., 2024).

Conversely, unhealthy lifestyle choices, such as poor dietary habits and physical inactivity, can have detrimental effects on gut health. A cross-sectional study showed that regular consumption of sweets and fast food was associated with higher rates of depression among Brazilian adults, highlighting the potential link between diets high in processed foods and sugars and gut dysbiosis, which is linked to mood disorders (Tavares de Sousa et al., 2013). Similarly, a case-control study identified that participants with high depressive symptoms often had dietary patterns rich in unhealthy foods, leading to poor gut health and an increased risk of depression (Xia et al., 2016).

These studies collectively underscore the importance of dietary habits in shaping gut health. A balanced diet rich in nutrients, coupled with regular physical activity, is crucial for maintaining a healthy gut microbiome and supporting overall mental and physical well-being.

- *Physical Activity and Its Impact on Gut Health*

Regular engagement in fitness activity is associated with numerous benefits for gut health and emotional well-being. Studies consistently show that individuals who engage in regular exercise have a more diverse gut microbiota and report better mood states compared to sedentary individuals. For example, research has demonstrated that athletes have a more diverse gut microbiota than non-athletes, suggesting that physical activity supports gut health by fostering a varied microbial environment (Clarke et al., 2014). This diversity enhances the gut's ability to resist pathogens and improve metabolic function.

Additionally, professional athletes exhibit higher metabolic functionality in their gut microbiota, underscoring the significant role of exercise in optimizing gut health (Barton et al., 2017). The increased metabolic activity observed in athletes may be linked to the enhanced production of short-chain fatty acids (SCFAs), which have anti-inflammatory properties and contribute to maintaining a healthy gut environment.

Cardiorespiratory fitness has also been shown to predict increased microbial diversity, reinforcing the idea that physical fitness is closely linked to a healthy gut microbiome (Estaki et al., 2016). This increased diversity is associated with various health benefits, including improved digestion, nutrient absorption, and immune function.

Furthermore, regular exercise enhances gut microbiota diversity, supporting a healthier gut environment (O'Sullivan et al., 2015). Exercise-induced changes in gut microbiota may contribute to improved mental health by modulating the gut-brain axis, which plays a crucial role in emotional and cognitive functions.

Overall, these findings suggest that physical activity positively influences the gut-brain axis, promoting overall health. Regular exercise not only enhances gut microbiota diversity but also supports mental well-being, highlighting the importance of incorporating physical activity into a healthy lifestyle for optimal gut and emotional health.

- *Sleep Quality and Its Impact on Gut Health*

Sleep quality is a critical factor influencing gut health, with poor sleep linked to alterations in gut microbiota and increased stress levels. Studies have shown that inadequate sleep quality and quantity are associated with reduced gut microbiome richness and diversity. For example, research has demonstrated that poor sleep measures, such as variability in night-to-night sleep duration, lower sleep efficiency, and worse self-reported sleep quality, are associated with lower gut microbiota diversity (Holzhausen et al., 2024). This relationship suggests that sleep quality may play a significant role in shaping the composition of the gut microbiome.

Moreover, better sleep quality has been associated with higher microbial diversity in young, healthy adults, highlighting the importance of maintaining good sleep habits to support a diverse and healthy gut microbiome (Grosicki et al., 2020). Good sleep patterns are crucial for maintaining a gut microbiome rich in butyrate-producing bacteria, which are linked to various health benefits (Estaki et al., 2022). Although the direct impact on emotional well-being was not a primary focus of these studies, the findings underscore the potential importance of sleep in promoting gut health, which is a significant contributor to overall well-being.

Overall, these findings indicate a close connection between sleep quality and gut health, suggesting that adequate sleep may help support a diverse gut microbiota. Further research is needed to explore the causal relationships between sleep, gut health, and emotional well-being, as well as the mechanisms underlying these interactions.

- *Smoking and Its Impact on Gut Health*

Smoking is a significant lifestyle factor that negatively impacts gut health and emotional well-being. It alters gut microbiota composition, leading to an increased risk of gastrointestinal diseases and metabolic disorders. Studies have highlighted how smoking affects the gut microbiome, revealing changes that may have profound implications for health. A research has shown that smoking is associated with changes in the relative abundance of Actinobacteria within the intestinal microbiota, potentially increasing the risk of metabolic and gastrointestinal disorders (Sublette et al., 2020).

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Further investigation into the relationship between tobacco smoking and gut microbiota composition has demonstrated that smoking behaviors lead to significant alterations in the abundance of specific gut bacteria, disrupting the delicate balance of the microbiome (Fan et al., 2023). This dysbiosis can have far-reaching consequences for overall health, as smoking has been causally linked to changes in gut microbiota through a bidirectional Mendelian randomization approach. The study also explored how the gut microbiota might influence smoking behaviors via the microbiota-gut-brain axis, suggesting that the microbiome could impact brain function by producing neurotransmitter-associated metabolites. This complex feedback loop indicates that the gut microbiota not only responds to smoking but may also play a role in the initiation and maintenance of smoking habits, highlighting the potential for microbiota-targeted interventions to support smoking cessation efforts.

In individuals with type 2 diabetes, smoking influences the gut microbiota by altering the relative abundance of specific bacterial taxa, such as an increased proportion of the Coprococcus genus, which could negatively impact gut health (Kondo et al., 2022). This emphasizes the multifaceted impact of lifestyle factors on gut health and underscores the need for smoking cessation and lifestyle modifications to optimize gut health and improve overall well-being.

Overall, these findings illustrate the significant impact of smoking on gut health, highlighting the need for lifestyle changes to optimize gut microbiota composition and promote overall health. Understanding the interactions between smoking, gut health, and emotional well-being is crucial for developing effective strategies to mitigate the negative effects of smoking on health.

- *Alcohol Consumption and Its Impact on Gut Health*

Excessive alcohol consumption is a lifestyle factor that can negatively impact gut health and mood. Alcohol, particularly in large amounts, disrupts gut microbiota and damages the gut lining, leading to increased gut permeability, often referred to as "leaky gut." This disruption can have significant consequences for both physical and mental health. Research has shown that alcohol consumption can compromise the integrity of the gut barrier. Acute alcohol consumption in healthy male volunteers led to a significant increase in markers of gut wall damage, such as intestinal fatty acid binding protein (I-FABP) and liver fatty acid binding protein (L-FABP) (De Jong et al.,2014). These findings suggest that alcohol weakens the gut barrier, a crucial component of the gut-liver axis. Although the study did not find evidence of systemic inflammation or endotoxemia following acute alcohol consumption, chronic or heavy alcohol use could potentially lead to these issues. Disruptions to the gut-liver axis due to increased gut permeability from alcohol consumption may contribute to mental health challenges like depression and anxiety.

Furthermore, the impact of alcohol on the gut microbiota is significant. (Bajaj et al.,2020) conducted a randomized clinical trial to evaluate the effects of fecal microbiota transplantation (FMT) on patients with alcohol use disorder (AUD) and cirrhosis. The study highlighted that chronic alcohol consumption leads to systemic inflammation and disrupts the balance of the gut microbiota, exacerbating the symptoms of AUD and the progression of cirrhosis. FMT was shown to counteract these detrimental effects by introducing a healthier microbial community into the gut, resulting in reduced markers of systemic inflammation such as IL-6 and LBP. This suggests that FMT can help restore a more favorable gut environment and alleviate symptoms associated with AUD and cirrhosis. Additionally, the study found that FMT was associated with improvements in gut health outcomes, including increased microbial diversity and the abundance of beneficial bacteria that produce short-chain fatty acids (SCFAs). These SCFAs are important for maintaining the health of the gut lining and may play a role in reducing alcohol cravings and consumption.

Overall, these findings illustrate the significant impact of alcohol consumption on gut health, emphasizing the need for interventions that modulate the gut microbiota to mitigate the negative effects of alcohol. Understanding the interactions between alcohol, gut health, and mental well-being is crucial for developing effective strategies to address the adverse effects of alcohol consumption on health.

- *Mindfulness and Its Impact on Gut Health*

Mindfulness practices, such as meditation and yoga, can positively affect gut health and mood by reducing stress and enhancing emotional regulation. These practices help decrease stress-related gut symptoms by promoting relaxation and reducing the body's stress response. Mindfulness-Based Stress Reduction (MBSR) has been shown to significantly reduce the severity of Irritable Bowel Syndrome (IBS) symptoms and improve quality of life, as it leads to a reduction in IBS symptom severity and self-reported stress, with improvements maintained over time (Zernicke et al., 2012). Mindfulness enhances emotional regulation and reduces stress, which can alleviate IBS symptoms by influencing the brain-gut axis—a communication system between the central nervous system and the gastrointestinal tract that involves neural, endocrine, and immune pathways.

Mindfulness practices can also help manage stress, known to exacerbate IBS symptoms, by fostering awareness and nonjudgmental acceptance of present-moment experiences. This approach helps individuals with IBS manage their symptoms and improve their quality of life. Improvements in IBS severity and emotional regulation are linked to stress reduction and increased body awareness, enhancing gut function by shifting the autonomic nervous system from sympathetic to parasympathetic dominance (Gaylord et al., 2011).

In addition, mindfulness is associated with improved health-related quality of life in individuals with inflammatory bowel disease (IBD), highlighting its role in modulating the gut-brain axis. Higher levels of mindfulness correlate with better quality of life in IBD patients, suggesting that mindfulness-based interventions could be beneficial for managing symptoms and improving well-being

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(Christodoulou et al., 2024). By fostering a positive mental state, mindfulness may help maintain a balanced gut microbiome, leading to improved emotional health.

Overall, mindfulness practices offer a non-pharmacological approach to managing gut-related conditions by reducing stress and improving emotional regulation. These benefits contribute to a healthier gut-brain axis, emphasizing the importance of holistic healthcare approaches, particularly for individuals with chronic conditions like IBS and IBD.

➢ *Stress and Its Impact on Gut Health*

Stress is a significant factor that negatively impacts gut health and emotional well-being. Chronic stress is linked to alterations in gut microbiota and increased gut permeability, which can contribute to inflammation and mood disturbances. This relationship is mediated by the gut-brain axis, a bidirectional communication network between the gut and the central nervous system, involving mechanisms such as the hypothalamic-pituitary-adrenal (HPA) axis and the vagus nerve.

Under stress, the body's physiological responses can lead to changes in the gut environment. Stress hormones such as cortisol can disrupt the balance of gut microbiota, leading to dysbiosis (Wauters et al., 2022). This imbalance may increase gut permeability, often referred to as "leaky gut," allowing bacteria and toxins to pass through the gut lining into the bloodstream and potentially triggering systemic inflammation (Papalini et al.).

Studies have shown that stress can exacerbate gut-related issues, such as increased intestinal permeability and changes in gut microbiota composition. For example, stress-induced hyperpermeability has been observed in various studies, highlighting the potential for stress to compromise the gut barrier and negatively affect gut health (Wauters et al., 2022).

In addition to impacting gut physiology, stress can also affect mental health through its interactions with gut microbiota. Research suggests that stress can alter the gut microbiota, influencing cognitive and emotional responses. For instance, stress-related changes in the gut microbiome have been linked to increased cognitive reactivity and mood disturbances (Chahwana et al.). Moreover, stress can impair cognitive performance and emotional resilience, further affecting overall well-being (Papalini et al.).

These findings emphasize the importance of understanding the impact of stress on gut health and the need for strategies to mitigate stress-related effects on the gut-brain axis. Maintaining a healthy lifestyle and managing stress effectively can help support gut health and improve mental and emotional well-being.

➢ *Antibiotics and Their Impact on Gut Health*

Antibiotics are known to disrupt the balance of gut microbiota, leading to reduced microbial diversity and long-term implications for gut health. These disruptions can alter the composition and function of the microbiome, affecting overall health and increasing susceptibility to various diseases. Research has shown that antibiotics can have immediate and dramatic effects on gut bacteria. For instance, Mikkelsen et al. (2015) observed that a four-day course of broad-spectrum antibiotics resulted in a significant reduction in the abundance of gut bacteria in healthy, glucose-tolerant males.

Similarly, studies have demonstrated a significant reduction in gut microbiota diversity following the use of broad-spectrum antibiotics, underscoring the negative impact on gut health. The gut microbiota plays a crucial role in various physiological processes, including nutrient metabolism, development and maintenance of the immune system, and protection against pathogens (Lankelma et al., 2016). These findings highlight the potential consequences of antibiotic use on the gut microbiota, which is increasingly recognized as vital to overall health and disease prevention.

Early-life exposure to antibiotics can have lasting effects on gut microbiota development. For example, infants treated with antibiotics exhibited significant alterations in their gut microbiome, potentially influencing metabolic and immune system development (Reyman et al., 2022). Research has identified that various non-antibiotic drugs also impact gut microbiota. Many pharmaceuticals can affect microbial composition, indicating a broader impact beyond antibiotics alone (Maier et al., 2017).

The use of antibiotics can also lead to increased antimicrobial resistance, highlighting the need for cautious use. Indiscriminate use of antibiotics contributes to macrolide resistance, emphasizing the importance of preserving microbial balance to prevent resistance and maintain overall health (Pickering et al., 2022).

These findings underscore the importance of understanding the impact of antibiotics on gut health and the need for responsible antibiotic use. Maintaining a balanced gut microbiota is crucial for supporting physiological processes, immune function, and overall well-being.

➢ *Prebiotics and Probiotics and Their Impact on Gut Health*

Prebiotics and probiotics are integral components of maintaining gut health, which plays a significant role in supporting mood and emotional well-being. Probiotics are live microorganisms that confer health benefits, while prebiotics are dietary fibers that nourish beneficial bacteria. Together, they work synergistically to enhance gut microbiota composition and function. Studies have shown that the use of probiotics can lead to significant health improvements; a multistrain probiotic preparation was found to significantly reduce symptoms of irritable bowel syndrome (IBS) by improving gut health, which can be associated with better emotional health outcomes (Williams et al., 2008). While this particular study focused on IBS symptoms, the broader context of gut-brain research suggests a link between gut health and emotional health, mediated by the gut-brain axis.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV235

The synergistic effects of combining probiotics and prebiotics, known as synbiotics, have also been demonstrated in research. Co-supplementation with probiotics and inulin prebiotics has been shown to significantly improve metabolic profiles, underscoring the role of synbiotics in promoting a healthy gut environment that can positively affect mood and mental health (Liu et al., 2024). Moreover, synbiotic interventions have led to significant enhancements in gut microbial diversity, contributing to better gastrointestinal health and potentially influencing emotional stability (Worthley et al., 2009).

Probiotics have also been shown to directly influence mental health; probiotic supplementation has been associated with a significant reduction in depressive symptoms, emphasizing the gut-brain axis's role in modulating mood through improved gut health (Kazemi et al., 2018). Probiotics and prebiotics may influence mental and emotional health through various mechanisms, such as modulating gut microbiota, impacting neurotransmitter production, reducing inflammation, and altering tryptophan metabolism. By increasing the population of beneficial bacteria and influencing pathways like serotonin production, they can improve mental health outcomes.

Certain probiotic strains have demonstrated specific psychobiotic effects, further supporting their role in stress management and mental well-being. Consumption of Bifidobacterium longum 1714 has been associated with reduced stress responses and improved memory, supporting the potential of psychobiotics in stress management (Allen et al., 2016). Another study found that probiotics containing Bifidobacterium bifidum BGN4 and Bifidobacterium longum BORI significantly reduced inflammation-causing gut bacteria, improved mental flexibility, and increased brain-derived neurotrophic factor (BDNF) levels, which are crucial for neuroplasticity and mood regulation (Chong-Su Kim, 2021).

These studies collectively illustrate how prebiotics and probiotics can foster a balanced gut microbiome, reduce inflammation, and enhance the production of neurotransmitters, thereby supporting mental and emotional health through the gut-brain axis. The evidence highlights the potential of these interventions not only in managing gastrointestinal disorders but also in improving mood and cognitive functions, emphasizing the importance of targeted dietary strategies for mood.

II. METHODOLOGY

A. Inclusion Criteria:

- **Relevance**: Studies that directly examine the relationship between lifestyle factors (diet, exercise, sleep, etc.) and gut health or emotional well-being.
- **Language**: Articles published in English.
- **Publication Type**: Peer-reviewed journal articles, Human clinical trials.
- **Population**: Studies involving human subjects, 18 years old and above globally.

B. Exclusion Criteria:

- **Irrelevance**: Studies that do not focus on the gut-brain axis or lifestyle factors impacting gut microbiome.
- **Non-English**: Articles not available in English.
- **Animal Studies**: Research involving animal subjects instead of human participants.
- **Opinion Pieces**: Includes editorials, letters, reviews, and non-peer-reviewed articles.

C. The Databases Searched Included:

- PubMed**,** Google Scholar
- ResearchGate
- Web of Science.

D. Search Strategy:

A comprehensive search strategy was developed using a combination of keywords and Medical Subject Headings (MeSH) terms related to lifestyle factors, gut health, and emotional well-being. The search terms included "lifestyle," "gut health," "emotional well-being," "dietary habits," "physical activity," "sleep patterns," "smoking," and "alcohol consumption." Boolean operators (AND, OR) were used to combine search terms.

E. Study Selection:

The selection process for the studies included in this review followed a structured and comprehensive approach. A total of 227 studies were initially found through searches in Scopus (n=65), PubMed (n=112), and Web of Science (n=50). After removing 18 duplicate references, 209 studies were screened based on their titles and abstracts, leading to the exclusion of 124 irrelevant studies. The remaining 85 studies were then assessed for eligibility, resulting in the exclusion of 72 studies due to various reasons: animal studies (n=20), non-English papers (n=7), wrong study design (n=12), lack of open access (n=8), wrong outcomes (n=5), review papers (n=15), and non-peer-reviewed studies (n=5). Finally, 13 studies met the inclusion criteria and were included in the review, ensuring a focused and high-quality analysis of the topic under investigation.

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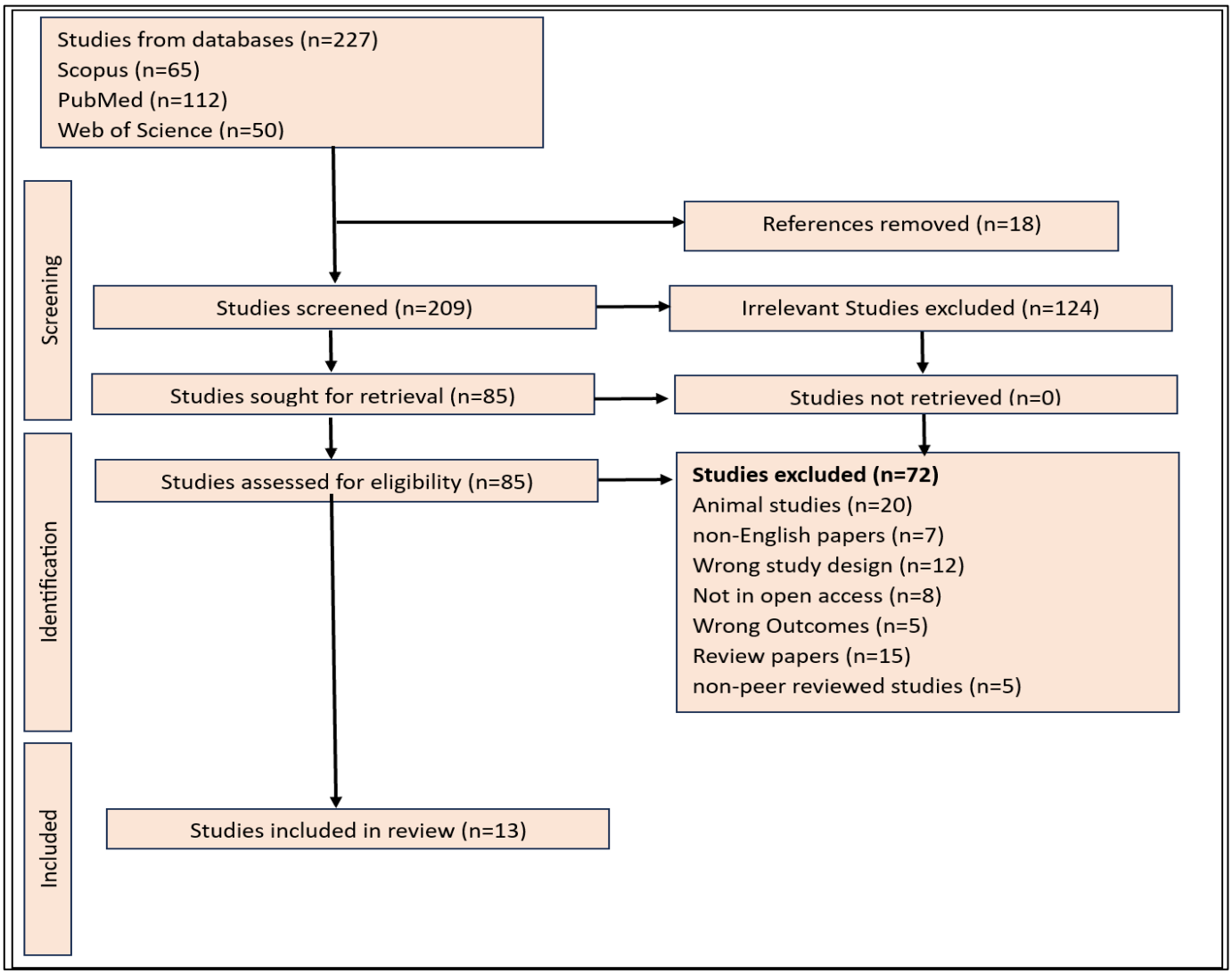

Fig 1: Flow Diagram of Study Selection

III. RESULT AND DISCUSSION

Table 1: Summary of the Studies Included in the Review

Author's name	Place of Study	Type of Study	Intervention	No. of Participants (N)	Duration	Biomarkers and psycho analysis score	Results
Madan et al. (2019)	Houston, TX, USA	Observational cohort study	N/A	111	1 year	Depression (PHQ-9) and anxiety (GAD-7); Gut microbiota richness and alpha diversity	↓ Gut microbiota richness & α-diversity = ↑ depression/anxiety severity. ↑ Richness/diversity early in hospitalization = depression remission at discharge. *Coprococcus catus* (butyrate producer) key in gut-psychiatric health link.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV235

Mikkelsen et al. (2015)	Denmark	Prospective clinical study	Broad-spectrum antibiotic cocktail	12	4 days	Gut microbiota composition; PPG tolerance; Insulin secretion; Plasma lipid levels; Gut hormone release	Antibiotic course ↓ gut bacteria abundance, confirming its disruption. Despite this, PPG tolerance, insulin secretion, & plasma lipid levels stayed unchanged. However, a temporary ↑ in PYY secretion (fullness hormone) was observed.
Rinott et al. (2022)	Israel	RCT	Compared 3 dietary interventions : (HDG), (MED) & (Green-MED).	294	1 year 6 months	Gut microbiome composition and function; Body weight; Cardiometabolic biomarkers; Adherence to dietary interventions	The Green-Mediterranean diet, rich in plant-based foods, ↑ *Prevotella* (linked to better digestion & immune function), enhancing gut health. Participants also saw weight loss & improved cardiovascular and metabolic health markers.
Adjibade et al. (2019)	France	Prospective cohort study	None (observational study)	26,730	Mean follow-up of 5.4 years	Incident depressive symptoms	A 10% ↑ in UPF = 21% ↑ risk of depressive symptoms. Significant associations were also found with UPF intake in groups like beverages, sauces, & added fats, especially in those with lower energy intake relative to needs
Sousa et al. (2019)	Brazil	Cross-sectional	None (observational study)	46,785	2013 Brazil NHS	healthy food markers; unhealthy food markers; Nutritional score based on food marker frequency; PHQ-9	↑ Sweets, snack-based meal replacements, & sugar-sweetened beverages = ↑ depression risk. Conversely, ↑ beans & higher nutritional score (healthier diet) = ↓ depression risk. The study

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							emphasizes the strong link between dietary habits & depressive symptoms
Zernicke et al. (2012)	Calgary, Canada	RCT	(MBSR)	90	8 months	IBS symptom, stress, mood, QOL	MBSR group ↓ IBS symptom severity & non-GI symptoms (stress/mood).
Guevara-Cruz et al. (2019)	Mexico City, Mexico	RCT	reduced-energy diet, a low-saturated-fat diet (LSFD), and functional foods	According to inclusion and exclusion criteria	2 months.	Anthropometric variables; serum biochemical parameters; gut microbiota composition; and serum lipopolysaccharide levels.	Specific gut microbiota changes included ↑ *Akkermansia muciniphila* (strengthens gut barrier, ↓ inflammation) and *Faecalibacterium prausnitzii* (butyrate producer, protects against IBD), linked to better gut & metabolic health. The lifestyle intervention also led to significant improvements in metabolic syndrome components.
Barton et al. (2018)	Ireland	Observational	N/A	86	N/A	Gut microbiome composition & activity; Correlation with lifestyle parameters (e.g., dietary habits)	Athletes vs. sedentary: distinct gut bacteria & metabolic functions. Athletes = more diverse, active microbiome with ↑ beneficial compounds (e.g., SCFAs).
Holzhausen et al. (2024)	Wisconsin, USA	Cross-sectional	None (observational study)	720	1 year	Associations between gut microbiome richness, diversity, and composition with sleep measures.	Poor sleep = ↓ gut microbiome richness & diversity. Sleep pattern variability ↔ changes in gut bacteria types, suggesting sleep habits directly influence gut health via the gut-brain axis.

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Sublette et al. (2020)	WI, USA	Prospective RCT	Smoking cessation therapies	36	3.5 months	Bacterial diversity measures; CVD risk factors; Arterial function measures	Quitting smoking alters gut bacteria: ↑ beneficial *Bacteroidetes* and ↓ *Firmicutes*; quitting smoking = ↓ CVD risk factors.
De Jong et al. (2015)	Netherlands	RCT with crossover design	Alcohol vs water	15	24 hour period	Serum I-FABP, L-FABP, AST, ALT, GGT, LBP, and sCD14	Acute alcohol consumption damages enterocytes, evidenced by ↑ I-FABP levels. While L-FABP, AST, ALT, GGT were measured for liver cell damage, the primary finding was significant enterocyte damage.
Wauters et al. (2022)	Belgium	RCT	Lactobacillus rhamnosus CNCM I-3690-containing milk	92	4 weeks	LMR, salivary cortisol, STAI, PSS	Psychological stress ↓ intestinal barrier function, causing ↑ intestinal permeability ('leaky gut'). *Lactobacillus rhamnosus* CNCM I-3690 ↓ stress-induced gut effects.
Liu et al., 2023	Kermanshah, Iran	RCT	Prebiotic inulin, probiotic Lactobacillus rhamnosus; placebo	92	60 days	Gut microbiota composition; CB receptor expression; Serum levels of IL-6, TLR-4, LPS, TAC, MDA	Synbiotics (prebiotics + probiotics) = ↑ gut health. Inulin + *Lactobacillus rhamnosus* ↓ F/B ratio (key gut/metabolic marker), ↓ IL-6, LPS, TLR-4, & ↑ TAC, indicating ↓ inflammation & oxidative stress. CB2 expression (gut barrier & inflammation) also influenced.

Higher gut microbiota richness and alpha diversity, which measure the variety and abundance of microbial species in the gut, are consistently associated with better mental health outcomes, particularly in reducing the severity of psychiatric symptoms like depression and anxiety. These symptoms are typically assessed using tools such as the PHQ-9 and GAD-7, where higher scores indicate more severe symptoms. Studies have shown that individuals with a more diverse gut microbiome tend to have lower PHQ-9 and GAD-7 scores, suggesting less severe depression and anxiety. This relationship underscores the importance of maintaining gut microbiota diversity for mental health (Madan et al., 2019).

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Disruption of this delicate balance can have significant consequences. Broad-spectrum antibiotics, for instance, lead to a substantial reduction in gut bacteria abundance, which disrupts the overall composition of the gut microbiome. Although this reduction did not immediately affect glucose tolerance or insulin secretion, the long-term implications for mental health are concerning, as a decrease in microbial abundance poses a risk for worsening psychiatric symptoms (Mikkelsen et al., 2015).

Diet also plays a crucial role in influencing gut microbiota and, consequently, mental health. Diets high in ultra-processed foods (UPF) are associated with an increased risk of depressive symptoms. This correlation between poor dietary choices and negative mental health outcomes underscores the impact of gut microbiota composition, particularly when harmful bacteria become more prevalent (Adjibade et al., 2019). Additionally, the regular consumption of unhealthy foods, such as sugar-sweetened beverages, sweets, and snacks, further exacerbates the risk of depression, emphasizing the need for a balanced diet to support a healthy gut microbiome (Sousa et al., 2019).

Conversely, a healthy diet has a protective effect on mental health through its positive impact on gut microbiota. In a study comparing three dietary interventions—healthy dietary guidelines (HDG), the Mediterranean diet (MED), and the Green-Mediterranean diet (Green-MED)—the Green-MED diet, which emphasizes plant-based foods, was particularly effective in improving gut health. The diet led to an increase in the abundance of ‘Prevotella’, a genus of bacteria associated with positive health outcomes such as improved digestion and enhanced immune function. Participants on the Green-MED diet also experienced weight loss and improvements in cardiometabolic biomarkers, such as blood pressure, lipid levels, insulin sensitivity, and inflammatory markers, illustrating how specific dietary patterns can positively influence both gut microbiota composition and overall health (Rinott et al., 2022).

Moreover, regular consumption of healthy foods such as beans, vegetables, fruits, and natural fruit juices has been shown to lower the risk of depression. These foods are rich in fiber and antioxidants, which support the growth of beneficial gut bacteria and reduce inflammation. The negative association between these dietary choices and depressive symptoms, as measured by the PHQ-9 questionnaire, highlights the importance of a nutrient-rich diet for maintaining mental health (Sousa et al., 2019).

Lifestyle interventions that include a reduced-energy diet, a low-saturated-fat diet (LSFD), and the incorporation of functional foods have also been shown to positively alter gut microbiota composition. Specific alterations include an increase in the abundance of ‘Akkermansia muciniphila’, a bacterium known for strengthening the gut barrier and reducing inflammation, and ‘Faecalibacterium prausnitzii’, a key producer of butyrate, which has anti-inflammatory effects and protects against disorders like inflammatory bowel disease. The intervention led to improvements in components of metabolic syndrome (MetS), including reductions in body weight, BMI, waist circumference, blood pressure, serum glucose, triglycerides, and C-reactive protein (CRP) levels, along with an increase in HDL cholesterol levels. These changes in gut microbiota and metabolic health underscore the critical role of diet in maintaining gut and overall health (Guevara-Cruz et al., 2019).

Sleep quality, both objectively and subjectively measured, is intricately linked to gut microbiota richness, diversity, and composition. Poor sleep, characterized by inconsistent patterns, low sleep efficiency, and poor sleep quality, has been associated with reduced richness and diversity in the gut microbiome. This reduction negatively impacts the gut’s overall health and contributes to the worsening of psychiatric symptoms, demonstrating how sleep disturbances can weaken the gut’s microbial composition and exacerbate mental health issues (Holzhause et al., 2024). The study found associations between these sleep measures and specific changes in the gut microbiome, suggesting that disruptions in sleep can lead to alterations in the types of bacteria present, further compromising mental well-being.

The composition and functional metabolic activity of the gut microbiome also differ significantly between individuals with varying levels of physical activity. A study comparing professional athletes to sedentary controls found that athletes had a more varied and active gut microbiome. The athletes' microbiomes were characterized by a higher abundance of beneficial compounds, such as short-chain fatty acids (SCFAs), which are produced by gut bacteria and have anti-inflammatory properties. This suggests that physical activity enhances the gut's ability to produce helpful substances, further supporting the notion that a healthy lifestyle, including regular exercise, contributes to better gut and mental health (Barton et al., 2018).

Alcohol consumption also presents significant risks to gut health. Acute alcohol intake has been shown to cause damage to the intestinal lining, as evidenced by increased levels of intestinal fatty acid-binding protein (I-FABP), a marker of enterocyte damage. This damage compromises the gut barrier, leading to disruptions in gut microbiota and potentially worsening mental health outcomes by promoting systemic inflammation (De Jong et al., 2015).

Smoking cessation has also been shown to significantly alter gut microbiota composition. Quitting smoking led to an increase in the abundance of *Bacteroidetes*, a phylum of bacteria that plays a crucial role in digestion and metabolism, and a decrease in *Firmicutes*, which are often associated with higher fat absorption. These changes were accompanied by improvements in cardiovascular health, including better heart rate, blood pressure, and reduced inflammation, as well as a decrease in the relative abundance of bacterial taxa linked to negative health outcomes. The study's findings highlight the potential of smoking cessation to restore a healthier gut microbiome and improve overall health outcomes (Sublette et al., 2020).

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Stress also exacerbates gut health issues by negatively affecting the intestinal barrier, increasing intestinal permeability—often referred to as "leaky gut." This condition is measured using the lactulose-mannitol ratio (LMR), which involves the ingestion of two sugars: lactulose and mannitol. Mannitol, a small molecule, is easily absorbed by a healthy intestinal lining, representing normal absorption, whereas lactulose, a larger molecule, should not be absorbed as easily in a healthy gut. An increased LMR indicates that lactulose is passing through the gut lining more than it should, signaling increased intestinal permeability. This allows harmful substances to pass into the bloodstream, triggering systemic inflammation and further compromising mental health as the gut-brain axis becomes disrupted (Wauters et al., 2022).

Stress management techniques, such as the Mindfulness-Based Stress Reduction (MBSR) program, have been shown to positively impact gut and mental health. The MBSR program, which typically includes mindfulness meditation, body awareness, and yoga, led to significant reductions in IBS symptom severity, as well as improvements in stress, mood, and quality of life (QOL). The reduction in stress-related symptoms and the improvement in overall well-being suggest that stress management can help maintain a healthy gut microbiome, further supporting mental health (Zernicke et al., 2012).

Finally, supplementation with prebiotics and probiotics has been shown to beneficially influence gut microbiota composition and reduce inflammation. In a study involving the administration of prebiotic inulin and probiotic *Lactobacillus rhamnosus*, it was found that the combination (synbiotic) significantly improved gut microbiota composition, as indicated by a reduction in the Firmicutes/Bacteroidetes ratio, a marker often used to assess gut and metabolic health. Additionally, the synbiotic supplementation led to a decrease in inflammatory biomarkers such as interleukin-6 (IL-6), lipopolysaccharides (LPS), and toll-like receptor 4 (TLR-4), along with an increase in total antioxidant capacity (TAC), indicating reduced inflammation and oxidative stress. The study also observed that the synbiotic intervention influenced the expression of cannabinoid receptors, particularly CB2, which play a role in modulating gut barrier function and inflammation. These findings suggest that synbiotics could be a beneficial strategy for improving gut health, particularly in the context of inflammatory and metabolic disorders (Liu et al., 2023).

Overall, these studies highlight the complex interplay between lifestyle factors, gut microbiota, and health outcomes. A healthy diet, regular physical activity, stress management, and the use of probiotics can all contribute to a more diverse and balanced gut microbiome, which in turn supports better mental and physical health. Conversely, poor dietary choices, lack of exercise, alcohol consumption, smoking, and high levels of stress can disrupt gut microbiota composition, leading to a range of negative health outcomes. The findings underscore the importance of maintaining a healthy gut microbiome through lifestyle choices and interventions that support gut health.

IV. CONCLUSION

This review paper underscores the pivotal role that lifestyle choices play in influencing gut health and, consequently, mood and emotional well-being. Through a comprehensive analysis of existing studies, it was found that poor lifestyle habits—such as unhealthy dietary patterns, insufficient physical activity, inadequate sleep, and the frequent use of substances like alcohol and tobacco—are significantly associated with poor gut health. Individuals with poor gut health frequently experience gastrointestinal issues, such as bloating, indigestion, and irregular bowel movements, which are further linked to negative emotional states, including heightened stress, anxiety, and mood fluctuations.

Conversely, a healthy lifestyle characterized by balanced nutrition, regular exercise, sufficient sleep, and mindful eating habits is closely linked to good gut health. This, in turn, is associated with more stable and positive emotional well-being.

The study emphasizes the significance of a comprehensive approach to health, recognizing the interrelation between lifestyle, gut health, and mood. By addressing and improving lifestyle habits, individuals can potentially enhance their gut health, leading to better emotional health and overall quality of life. This review contributes valuable insights to the growing body of literature on the gut-brain axis and provides a foundation for future studies aimed at developing targeted interventions to improve both gut and mental health. The implications of these findings are significant for public health, suggesting that interventions promoting healthy lifestyles could be an effective strategy for improving both physical and mental health outcomes.

LIST OF ABBREVIATION

- ALT - Alanine Aminotransferase
- AST - Aspartate Aminotransferase
- AUD - Alcohol Use Disorder
- CB2 - Cannabinoid Receptor 2
- CRP - C-reactive Protein
- FMT - Fecal Microbiota Transplantation
- GAD-7 - Generalized Anxiety Disorder-7
- GBA - Gut-Brain Axis
- GGT - Gamma-Glutamyl Transferase
- GI – Gastrointestinal
- HDG - Healthy Dietary Guidelines
- IBD - Inflammatory Bowel Disease
- IBS - Irritable Bowel Syndrome
- I-FABP - Intestinal Fatty Acid Binding Protein
- IL-6 - Interleukin-6
- LBP - Lipopolysaccharide-Binding Protein
- L-FABP - Liver Fatty Acid Binding Protein
- LMR - Lactulose-Mannitol Ratio
- MBSR - Mindfulness-Based Stress Reduction
- MED - Mediterranean Diet
- N/A - Not Applicable
- OTC - Over-The-Counter

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- PHQ-9 - Patient Health Questionnaire-9
- RCT - Randomized Controlled Trial
- SCFAs - Short-Chain Fatty Acids
- sCD14 - Soluble Cluster of Differentiation 14
- TLR-4 - Toll-Like Receptor 4
- TAC - Total Antioxidant Capacity
- UPF - Ultra-Processed Foods

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