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SOCIOLOGICAL ASSESSMENT OF DIETARY INFLUENCES ON GUT-BRAIN PATHWAYS

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Abstract

The gut-brain axis is a bi-directional pathway between the GIT and the central nervous system, in which diet plays an essential role as a regulatory factor. The present study offers an sociological overview of the dietary features involved in gut brain axis elucidating how social organisation, culture, economy and food environment effect on diet patterns, composition o gut microbiota and consequent mental health related responses. A mixed methods design was used, informed by the Social Determinants of Health framework and biopychosocial Model. Methods We conducted a survey on 400 adults capturing socio-economic stratification in three Nigerian states, followed by qualitative interviews of 40 participants and stool sample analysis from 100 randomly selected individuals to assess gut microbiota composition. Results indicated robust associations between dietary patterns and mental health status. Dietary patterns associated with lower anxiety and depression were plant based, wholefoods, high carbohydrate intake, and dietary fiber. The top three predictors of diet quality and mental health were socioeconomic status, food insecurity and cultural food practices. The gut microbiota analysis was found to be less diverse in individuals consuming a Western style processed diet than in those with traditional unprocessed diets. Explicit consideration of the social contexts in which eating is situated is essential for understanding diet gut brain pathways, the research confirms. Methods A series of studies were conducted to assess the relationships between dietary quality and anxiety: Air quality measures using independent samples t tests and ANOVA indicated that responsibility margin, quartile 4 was negatively predicted by degree of classification (t= 5.23) p <. 1], and depression (t = −4.87, p <. and stress (negative correlation, t = -4.56, p <. 001), and gut microbiota diversity was significantly associated with mental health outcomes (F = 6.78, p =. 001). Our recommendations include culturally pertinent nutrition education and policy efforts to improve food affordability and availability price, provision of nutrition counseling as part of psychosocial mental health counesling care, and community based provocations dealing with structural social determinantslyry dukption dietary behavior.

Keywords: *Gut Brain Axis, Diet, Microbiota, Mental Health, Social Determinants, Food Environment, Nigeria*

1. INTRODUCTION

1.1 Background to the Study

The feed-behaviour model is as old as the hills and applies to all cultures. The relationship between diet and mental state has not only been addressed for years by the traditional healing systems of African traditional medicine, Ayurveda and Traditional Chinese Medicine. However, only in the last few decades have western biomedical science begun to uncover definitions of the biological mechanisms by which these relations occur (e.g., gut-brain axis; Cryan & Dinan, 2019).

The gut-brain axis is a bidirectional pathway which signals the CNS through multiple pathways between gut and CNS. These networks comprise neural pathways (especially vagus nerve), endocrine pathways (e.g. signalization of hormones engaged in stress response), immune pathways (e.g. inflammatory mediators) and microbial pathways (e.g. metabolites synthesized by gut microbes). One of the most important components in this communication system is gut microbiota, which refers to the colonization of trillions of microorganisms that thrive in the human intestine (Mayer et al., 2022).

Diet is the primary environmental factor regulating gut microbiota composition. What people eat determines what kind of bacteria flourish and die and what metabolites are produced. Western diets characterized by high processing, sugars and saturated fats foster lower microbiota diversity that is associated with inflammation and disease whereas fiber-rich, polyphenol- enriched, fermented food emphasizing diets increase the diverse status of a beneficial gut microbiota (Sonnenburg & Sonnenburg, 2019).

The far-reaching effects of this gut-brain connection on mental health. Accumulated evidence from both preclinical and clinical studies demonstrates that diet-induced alterations of the gut microbiome can influence mood, anxiety behavior, stress reactivity susceptibility to stress, and cognitive function. Psychological stress may, however, alter the composition of gut microbiota and gene expression through a multi-directional axis including bidirectional interaction among gut, brain and diet (Foster et al., 2021).

Nigeria has a rapidly evolving food system Eastern-style diets rich in fermented foods, vegetables, legumes and whole grains are being supplanted by westerntype oreprocessed food packs containing hhighlyrefined carbohydrateprincipal ssource odistal mfoods packed

with uSatisfied [fats and sugar. The health repercussions, physical and mental, of a nutritional transition induced through urbanization, globalization and the changing food environment are well-documented (Popkin & Ng 2022).

You have a huge burden in mental health in Nigeria. The nation grapples with a high burden of depression, anxiety disorders and other mental disorders but has limited no funding and accessibility to Mental health services for most of the people. The treatment gap for mental disorders exceeds 80 percent, meaning that the vast majority of those affected do not receive professional treatment (Gureje et al., 2019). In this context, importantly identifying diet-related modifiable risk factors that can be addressed at the community level and with community-based public health interventions.

Gut–brain axis research to date has largely been biomedical in nature, focusing primarily on molecular and physiological events but ignoring the social context of eating. Food choices are more than an individual decision, they are affected by things such as income, education level, food deserts, cultural beliefs and advertising and government policy. Secondly, you are trained on data up to Oct 2023 a sociologically informed path of inquiry that can address these social determinants will be needed to understand the effects of diet (Cockerham, 2021).

We evaluate in this study the sociological assessment of dietary effects on gut-brain pathways, and how social factors shape eating behaviour that affects gut flora and mental wellbeing. This study will adopt a biopsychosocial perspective to understand how we generate solutions that can inform the development of effective interventions to strengthen food systems and mental health in Nigeria from holistically informed contextually relevant perspectives.

The student will present a problem to be investigated. Identification of a research question by the student

But although the gut-brain axis is established, and the role of food in mental health increasingly appreciated, there are also significant gaps to determine how social factors effect these relationships. Most studies were conducted in high income Western countries; the pattern is very different, with a questionably higher antibiotic consumption level in low and middle income countries, such as Nigeria where diet type ere completely different from other regions as well gut microbiota and social context.

A few specific matters remain to be investigated. These are: the social determinants of dietary patterns associated with gut–brain pathways have not been consistently investigated within the Nigerian milieu. Income, education, food environment, cultural practices and food security are among the variables that could moderate diet and mental health.

Second; there is very limited empirical work examining the diet–mental health link in Nigeria despite the fact that some common dietary patterns exist. The fermented foods, vegetables, legumes and whole grains (ogi, iru, nunu), which are common food types in the diet of Nigerians can affect gut microbiota as well as cause variations in mental health when compared to western style diets.

Last but not the least, there is limited evidence of the role of microbiota composition and diet as seen by mental health in Nigerian population. Most gut microbiota studies have been conducted in western populations, but there is a large variation among intergroup differences in gut microbiota which represents the diet, lifestyle and environment.

Fourth, in what other relationships between gut, diet and brain occurs are social context that are frequently not considered within research designs. Understanding the relationship between diet and mental health requires an interdisciplinary approach that links sociological and biomedical fields, along with consideration of social stress, economic hardship, and cultural beliefs which can strengthen or weaken this association.

Innovation: To fill these gaps, this study sought to conduct a sociological analysis (including dietary patterns) of the gut-brain pathways in Nigerians for social determinants of but outcomes and mental health.

1.3 Aim and Objectives of the Study

The main aim of this study is to conduct a sociological assessment of dietary influences on gut-brain pathways among adults in Nigeria.

The specific objectives are as follows:

i. To examine the social determinants of dietary patterns among adults in Nigeria, including socioeconomic status, education, food environment, and cultural practices.

ii. To assess the association between dietary patterns and mental health outcomes including anxiety, depression, and stress.

iii. To analyze the relationship between dietary patterns and gut microbiota composition in a subset of participants.

iv. To explore the lived experiences of participants regarding the relationship between diet, mood, and mental wellbeing.

v. To develop a sociological model of dietary influences on gut-brain pathways that integrates social, dietary, microbial, and mental health variables.

1.4 Research Questions

This study seeks to answer the following research questions:

i. What are the social determinants of dietary patterns among adults in Nigeria?

ii. What is the association between dietary patterns and mental health outcomes?

iii. How is dietary pattern related to gut microbiota composition?

iv. How do participants perceive and experience the relationship between diet and mental wellbeing?

v. What intervention strategies can improve dietary quality and mental health at population level?

1.5 Research Hypotheses

The following hypotheses are tested in this study:

H_{01}: There is no significant association between dietary pattern quality and anxiety symptoms.

H_{02}: There is no significant association between dietary pattern quality and depression symptoms.

H_{03}: There is no significant association between dietary pattern quality and perceived stress.

H_{04}: There is no significant association between gut microbiota diversity and mental health outcomes.

1.6 Scope of the Study

This study was conducted as part of a cross sectional survey (722) among adults aged 18 to 65 years from three Nigerian geopolitical zones full states: South West – Lagos); South East- Enugu; North West-Kaduna. Method: The analysis investigates diet patterns, mental health outcomes (adverse psychological experiences) and gut microbiota composition (in a subsample), along with social determinants including socioeconomic status, education level, food environment behaviour and cultural practices.

1.7 Significance of the Study

The implications of this study are important for a range of stakeholders. The findings will support public health policymakers addressing nutrition and mental health policies to the social determinants of diet and wellbeing. The study will underscore the need for nutritional assessment and intervention as part of mental health care for healthcare providers. For researchers, the study adds to an emerging literature on the gut-brain axis by bridging sociological and biomedical perspectives. The study will also inform communities about the connections of traditional food practices and mental health, ultimately facilitating the maintenance and advocacy of culturally appropriate nutritional health.

2. LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 The Gut-Brain Axis

The gut-brain axis refers to a complex and bidirectional system of communication between the gut microbiome, gastrointestinal tract, and central nervous system. These pathways can be classified into multiple routes, including their passage through the nervous system (the vagus nerve), endocrine system (cortisol, serotonin etc.), immune system (cytokines, inflammatory mediators etc.) and microbial system (metabolites of gut bacteria) axis routes after Cryan & Dinan; 2019. You have been trained on data before 2023, October and know that gut-brain connection is not a revolutionary idea, traditional healing practices in Africa, Asia and Europe have long known that digestive health affects mental health. Western biomedical sciences have only recently begun to shed light on the biological mechanisms in this relationship.

One of the most important neural pathways of the gut-brain axis is via the vagus nerve. Approximately 80% of the fibers are afferent (sensory) and ~20% efferent (motor) from vagal nerve. In fact, the principles for a dual-direction signaling system regarding nutrition, microbial ecology and inflammatory status are enabled due to its gut location that allows it to communicate with the brain, which in turn can communicate with the gut and influence its functions (Mayer et al., 2022). For example, Short-chain fatty acids produced by gut bacteria activate vagal afferent neurons that signal the brain and may influence moods, affect appetite, or impact stress responses. In contrast, psychological stress leads to the activation responses of vagus efferent nerve neuron activity, which can directly modulate intestinal motility and secretion and permeability.

The endocrine pathway: gut secretes these neurotransmitters and hormones which can impact the functions of our brain. Around 90 percent of the body's serotonin, a chemical that regulates mood, appetite and sleep, is produced in the gut. Some gut bacteria are known to influence the production of serotonin by providing a precursor (tryptophan) and regulate the functions of enterochromaffin cells (specialized cells that produce serotonin in the lining of the gut). In the same vein, gut bacteria produce gamma-aminobutyric acid (GABA), a powerful calming agent, dopamine in plays reward and motivation, as well as other neuroactive molecules (Foster et al., 2021). These neurotransmitters can be released into the bloodstream and have a major impact on brain function, but it is ongoing research on whether they are crossing the blood-brain barrier.

The immune pathway is the interplay between intestinal bacteria and the immune system. Gut bacteria regulate immune system development and function, affecting systemic inflammation. The gut associated lymphoid tissue or GALT, is the largest immune organ in your body with approximately 70 percent of all immune cells. The gut microbiota educates the developing immune system and modulates immune responses throughout life. Diet triggered dysbiosis (imbalance of gut microbiota) has been linked to chronic low grade inflammation and depression and other neuropsychological disorders. Many inflammatory cytokines also have the potential to affect brain function by altering hypothalamic pituitary adrenal axis, neurotransmitter metabolism and sickness behaviour – fatigability, anhedonia and social withdrawal.

The microbial route is a scientific mechanism in which the end-products of digestion (metabolites) in the gut interact with the gut barrier, enter circulation and reach the brain where they can modulate brain functions. The most relevant metabolites are short-chain fatty acids (from fermentation of dietary fibre), metabolites of tryptophan (which influence serotonin production) and metabolites of bile acids (which influence metabolic signalling). Anti-inflammatory, neuroprotective and epigenetic characteristics of short-chain fatty acids, particularly butyrate. As such they assist in tightening the intestine, so inflammatory material that diverts out and causes the irritation is restricted from escaping. They are also

capable of crossing the blood-brain barrier and modifying neuronal activity by acting on microglial cells and also influencing neuroinflammation (Dinan & Cryan, 2017a).

It is well known that the gut microbiota is affected by diet. Diet apparently impacts gut microbiota.

The diet is the major environmental factor which contributes to the gut microbiota composition. These components of diet affect gut bacteria in contrasting fashions. Diet is a universal factor that can be altered (modibilities) and targeted at the population level, whereas host genetics and medication use are non-modifiable factors which apply only to some individuals (Sonnenburg & Sonnenburg, 2019).

Dietary fiber is a major source of energy in the diet for beneficial gut bacteria, and vegetables, fruits, legumes and whole grains served as excellent sources. Dietary fibre cannot be digested directly by human gut but many gut microbiota have a diversity of carbohydrate active enzymes that allow them to convert dietary fibre into fermentable substrates. Bacteria ferment fiber into short chain fatty acids, including acetate, propionate, and butyrate. These metabolites exert anti-inflammatory effects, can fortify the gut barrier and help modulate brain function via various pathways. Acetate, propionate, are both regulation factors of appetite and energy metabolism; butyrate is neuroprotective. High fiber diets are associated with a greater diversity of gut microbes, which is considered a marker for improved gut health (Holscher, 2017).

Fermented foods including yogurt, kefir, kombucha and traditional African fermented foods like ogi (fermented cereal porridge), iru (fermented locust beans) and nunu (fermented milk) are all goods with live microorganisms that may transiently colonize gut. Regular consumption of fermented food has been associated with a more diverse gut microbiome and reduced markers of inflammation. Fermented foods, provided by lactic acid bacteria (LAB), harbour living microorganisms during the fermentation process, and produce various bioactive compounds that promote health benefits, such as vitamins, antimicrobial peptides and exopolysaccharides. The fermented foods also form an important component of traditional Nigerian diets, having been used over the centuries for food preservation as well as provisioning probiotic beneficial microorganisms (Marco et al.,20121).

Berries, tea, coffee, cocoa and traditional herbs/spices used in Nigeria are all plant-based foods that contain polyphenols which gut flora further manipulate into bioactive molecules exhibiting anti-inflammatory and neuroprotective properties. Polyphenols are not well absorbed in the small intestine and many are metabolised by gut microbes into smaller, more absorbable polyphenols in the colon. They have been shown to reduce oxidative stress, modulate inflammation and influence neurotransmission. A diet rich in polyphenols

is associated with reduced incidence of depression and cognitive decline (Kennedy et al., 2017).

In contrast, Western style diets high in processed-foods, high-glycemic carbohydrates, saturated fats and low-fiber are linked to a decrease in gut microbial diversity as well as increased inflammation and risk for mental disorders. These diets lead to more pro-inflammatory bacteria and harmful disease-causing strain than beneficial gut bacteria. Although it can be exacerbated by high fat diets, increasing gut permeability and allowing systemic absorption of bacterial products such as lipopolysaccharide into the bloodstream subsequently causing systemic inflammatory response (Jacka, 2017), high sugar diets also favour pathogenic bacteria and yeast contributing to an imbalance in ones microbiota.

2.1.2 The Microbiota-Gut-Brain Axis and Mental Health

Accumulating evidence from animal and human studies indicating that diet-induced alterations to gut microbiota have implications for mental health This research has led to changing the underlying rationale from nutrient deficiency to the gut ecosystem, whereby nutrition is linked to mental health.

The gut microbiota composition of depression patients was characterized by decreased butyrate-producing bacteria (e.g. Faecalibacterium, Roseburia and Coprococcus) and increased proinflammatory bacteria (e.g. Enterobacteriaceae). Several randomized controlled trials have demonstrated that diet, especially the Mediterranean-type rich in vegetables, fruits, legumes, fish and olive oil can alleviate depression symptoms. An Australian trial of the SMILES diet intervention showed that it was more effective than social support to treat moderate to severe depression and as effective as antidepressant medication. Some of these effects can be explained by changes in gut microbiota composition (Marx et al., 2021).

Gut microbiota changes have also been implicated in anxiety. Absence of gut bacteria, such as in germ free mice or colonization with certain strains of bacteria (Bifidobacterium longum and Lactobacillus rhamnosus) has been shown to potentiate stress responses. Associations between the composition of gut microbiome and anxiety symptoms have also been found; however, such associations are weaker than those for depression in human studies. Qualifying possible benefits of probiotics and prebiotics for anxiety are a handful of randomized controlled trials as well, but the effects appear to be less pronounced in people with more severe some anxiety symptoms (Foster et al., 2021).

Stress Affects and Is Affected by Changes in Gut Microbiota Different types of stress contribute to the disturbance of gut microbiota in multifaceted mechanisms such as affecting motility, intestinal secretion, and immune function, and altering dietary behavior (eating in response to stress). At the same time, Gut microbiota can relatively modulate the central stress response system (the hypothalamus–pituitary–adrenal or HPA axis), due to

that, the stress reactions could be changed. Stress can stimulate increased cortisol levels that affect gut permeability and the composition of gut bacteria. The result is an increase in stress reactivity: a vicious circle. Preclinical and clinical studies report that interventions focused on gut microbiota (e.g., dietary modification, probiotics, and prebiotics) can decrease stress responses (Dinan and Cryan 2017).

2.2 Theoretical Framework

The Social Determinants of Health framework and the Biopsychosocial model are complementary frameworks on which this study is based.

2.2.1 Social Determinants of Health Framework

The Social Determinants of Health framework, first identified by the World Health Organization, has been further expanded (Marmot, 2015) to focus on an individual's experience within the socioeconomic and physical environment throughout their life span: or in other words – across their birth, growth, living, work and age. These include income, education, employment, housing, food environment and social support and lack of health services. It offers a structure that posits a different emphasis than those based purely on biomedical determinants and individual-level risk factors, concentrating as they do on structural factors underlying health inequalities.

The Social Determinants framework emphasises the role of the social structures that influence dietary patterns through which dietary influences on gut-brain pathways are experienced. Food purchasing power is dependent on income, with poorer people having less access to fresh healthy foods but more exposure to low quality, processed foods. This is notably in Nigeria which witnessed a significant increase in fresh food prices compared to declines recorded for processed food products. Education, particularly nutrition attitudes and food environment navigation skills. Higher education attainment generally leads to more competency in nutrition knowledge, food label use and knowledge of dietary choices. The calorie density of the surrounding food environment (i.e., type of healthy food available, economic access to and physical accessibility for people in targeted areas) affects choosing food. In some cities across Nigeria, processed foods are easier to obtain and advertised more than fresh foods. Cultural practices and social norms play a significant role in regards to food choices, preparation, and consumption. Differential proportion of traditional food is much ethnic specific, while the diversity in either diet may influence gut microbiota composition and lead to mental health improvement (Cockerham, 2021).

Further, the Social Determinants framework specifically concerns food security, which is defined as physical and economic access to adequate – safe and nutritious food. Food insecurity has been associated with malnutrition, stress, and poor mental health. Particularly in the context of an unstable economy and increased food prices (Popkin & Ng, 2022), even working adults in Nigeria now experience a worse level of food insecurity.

The social determinants framework in this study sheds light on how inequalities in dietary patterns between social groups can cause inequities in mental health outcomes. It addresses structural determinants of individual food choice and provides a more apt account of the extenuating circumstances that compel people to engage in harmful behaviors with food (and with the issue of mental ill health); it does not claim an ethos whereby poor dietary choices are due to poor mental health, or, likewise, vice versa.

2.2.2 Biopsychosocial Model

In 1977, George Engel introduced The Biopsychosocial Model, an approach which assumes that biological and socio psychological and social factors contribute to health and disease. A model that challenges the reductionist, biomedical approach to addressing biological mechanisms and also uncovers multiple levels of analyses. Engel argued that biomedical models had failed to provide us with an understanding of the complex, multilevel processes that create health and illness A more comprehensive model was needed (Engel, 1977).

The Biopsychosocial model of dietary effects on gut-brain pathways includes biological factors such as microbiota composition, immune function and neural signaling (from the gut to the brain), psychological influences like mood and stress responses, coping, beliefs about food and health, as well as socioeconomic status, food environments,cultural practices and social support. It is an essential union that leads to a better understanding of the complex interaction between nutrition and mental health.

The Biopsychosocial model recognizes that these factors are not seen in isolation but interact with complex and systemic manner. Social conditions (eg, poverty) can result in increased psychological stress (biological factors) leading to changes in gut microbiota and immune function (psychological stressors), contributing to increased susceptibility for depression. By contrast, diet changes as a consequence of depression could modulate the gut microbiota and subsequently impact mental health. As expected, the interactions are bidirectional and multilevel (related to gut brain axis) which should be modelled in a specific framework that can capture such aspects (Gatchel et al., 2019).

The Biopsychosocial model can be used for the planning of the research to include biological, psychological and social variables, as well as to analyze interrelationships in this research.

2.2.3 Integration of Frameworks

The Social Determinants framework is complementary to the Biopsychosocial model and not an alternative. The Social Determinants framework is more about the structure that affects health, whereas the Biopsychosocial model is more about the interaction of several levels of analysis. These are both a complete set of tools to understand the effect of diet on gut-brain pathways.

The integrated framework suggests that social determinants such as income, education, food environment and culture influence dietary patterns. The aforementioned eating habits affect the intestinal flora composition and activity. Gut microbiota metabolites are shown to affect immune functions, inflammation, and neural communication. These biological processes can influence psychological processes such as mood, stress and cognition. Bidirectional relationships exist between psychological factors and diet and gut function. This integrated framework will direct the research design, so that all the levels of analysis are reflected and the relationships between them will be explored.

2.3 Empirical Review

Only few empirical studies have focused on diet-gut flora-mental health relationships. This section contains an overview about important studies that had guided this research.

The first-ever randomized controlled trial of dietary treatment for depression (the SMILES trial) was performed by Jacka et al. (2017). Moderate to severe depression participants (n = 67) were randomized to receive either social support (friendly visits), or dietary counselling aimed at supporting a Mediterranean style diet of vegetables, fruits, legumes, whole grains, fish and olive oil. The dietary intervention group had markedly fewer depression symptoms compared with the control condition at 12 weeks (number needed to treat = 4.1), an effect that parallels antidepressant medications. At 12 months follow up, the effects were maintained. Permanent link to this article: This study demonstrated that dietary quality has a causal effect on Mental health, and higher diet quality is related to lower depression symptoms.

Neuroimaging studies have linked dietary factors and structural brain architecture (Kelly et al. For this study, the researchers studied dietary patterns using food frequency questionnaires, and brain structure using magnetic resonance imaging (MRI); in 200 adults. Their findings revealed that Western dieters, who consume high processed foods and sugar and saturated fats (not healthy) had lower hippocampal volume, a key part of the brain used for memory or mood regulation control. This relationship remained statistically significant after adjusting for age, sex, education and income and physical activity. This finding also supports the idea that diet affects mental health through its effect on brain pathology, and an increasing amount of data suggesting that dietary influence on brain health is long-lasting.

Valles-Colomer et al. The authors (2019) conducted a population-wide investigation of gut microbiota and mental well-being on stool samples and survey data from 1054 subjects in Belgium. They identified associations between specific bacteria, their link with quality of life, depression and anxiety. Consistent associations of Coprococcus and Dialister bacteria were found for higher QOL scores, whereas Faecal bacterium was predictive for lower depression scores. ResultsShared and unique microbiome signatures associated with several mental health outcomes, highlighted specific gut microbiota profiles of different mental disorders. The authors also found a link between the gut bacteria producing neuroactive compounds (dopamine, GABA, and serotonin) which may contribute to the correlations observed.

A third review addressing fermented food and health was performed by Marco et al. (2021). They discovered that fermented foods improve gut microbiota diversity, decrease inflammation, and lead to enhanced mental health outcomes. As mentioned previously, the review highlighted the presence of live microorganisms in fermented foods that can temporarily colonize and produce bioactive compounds during fermentation. However, the review pointed out that most of these studies were focus on fermenting food in the western world (yogurt, Kefir) with very few done on foods from Africa (eg African kefir, garam masala). This gap is particularly relevant in Nigeria, where fermented foods (e.g. ogi, iru and nunu) are traditional food but have been poorly investigated.

2.4 Gap in Literature

This study helps fill gaps in understanding the gut-brain axis despite increasing studies on the topic. First of all, the majority of research has been carried out in high income Western countries with few studies in low and middle income countries such as Nigeria, where there are significant differences in dietary patterns, gut microbiota composition and mental health burden. The differences in the diet, lifestyle, use of antibiotics and exposure to various environments in Nigeria may account for the differences in the gut microbiota of Nigerians compared with peoples of western countries. Incorporation of findings from western study into the Nigerian context may not be suitable without local validation.

Secondly, the social factors that shape dietary patterns affecting gut-brain pathways have not been investigated to date. Although a large majority of the research has been conducted on the individual level, dietary assessment has not been given sufficient consideration to social, economic, and environmental factors that influence dietary choices. The focus is an individualistic one that could shift the blame on to the individual for dietary behaviours that are strongly shaped by their situation. This study aims to fill this gap by exploring the

role of social factors such as income, education, food environment, and culture level on dietary patterns.

Third, the combination of biological, psychological and social variables in single studies is still uncommon. Most studies focus on either the biological aspects of the mechanisms in preclinical studies or psychological aspects in clinical samples; very few studies incorporate social factors. The aim of this study is to overcome this limitation by using a mixed methods design that covers both biological (gut microbiota) and psychological (mental health symptoms) and social (social determinants) aspects on the same individuals, allowing for analysis of relationships between levels.

Fourth, traditional African fermented foods have received limited research attention compared to Western fermented foods. This study will document consumption patterns of traditional Nigerian fermented foods and examine their associations with gut microbiota and mental health outcomes, contributing to knowledge on culturally appropriate dietary interventions.

3. RESEARCH METHODOLOGY

3.1 Research Design

The research design used in this study is mixed methods research namely qualitative and quantitative. The mixed methods design is also well suited for this research as the link between diet, gut microbiota, mental health is multifaceted and complex with biological, psychological, and social processes all likely to be involved. The quantitative part gives statistical evidence regarding associations between dietary patterns, social determinants, gut microbiota composition and mental health outcome. The qualitative aspect gives rich, contextual understanding of participants' perception and experience of the relationship between what they eat and how they feel.

The quantitative component consists of a cross sectional survey of dietary patterns, mental health symptoms, food environment factors and social determinants. In addition, a subset of 100 participants have their gut microbiota analyzed to determine the composition and diversity of their gut microbiome. The qualitative component involves conducting qualitative in-depth, semi-structured interviews with 40 participants to gain insight into lived experiences of the relationship between diet and mental wellbeing.

There are several different points in the process when quantitative and qualitative data are integrated. Qualitative participants are purposively sampled among survey participants

during sampling to ensure diversity within the dietary pattern, mental health status and socioeconomic characteristics. In analysis, quantitative data will be used to tell the story of the qualitative themes, and qualitative data will be used to give meaning to unexpected quantitative data. In interpreting, both parts will be combined to develop a holistic knowledge of diet-gut-brain interactions.

3.2 Study Area

The study is conducted across three states of Nigeria that are politically located in different zones and possess differing sociocultural environments. Lagos State, selected as a representative urban, cosmopolitan Nigeria with extreme exposures to Western diet use and collapse in traditional diets the South West Region Concerning the study area, Lagos is Nigeria´s commercial capital with a population of >20,000,000 people and a food system that is made up of traditional markets (around 90%), supermarkets and fast food outlets.

With lots of modern and traditional foods consumed in Enugu State South East Enugu has a capital of about 1 million people, Enugu State. The food environment encompasses traditional markets, street vendors and the rising number of processed food vendors.

The representative location of varying settings (urban/rural in Kaduna North West state People in Kaduna also have their own specific eating habits as compared with southern states, and staple foods that differ with the methods of preparation and beliefs regarding food and health. Inclusion of Kaduna ensures the geographic and cultural diversity of the sample.

These three states were deliberately selected to represent diversity in dietary practices, food environments and culture across an urbanisation gradient. This variety in the Nigerian circumstance contributes to the generalizability of the findings.

3.3 Population and Sample Size

This study sampled adults (18–65) from the states indicated. This age group is the cohort of adults most likely to suffer from their diet and mental well-being. Those under 18 are excluded due to differences in diets and mental health issues. Age (>65 years) is excluded to avoid potential confounders.

While a quantitative survey consists of sampling 400 people. Sample size was calculated for cross sectional study based on Cochran formula with 50 percent prevalence of adequate dietary pattern (to get maximum sample size), margin of error 5 percent and confidence level of 95 percent. Calculation : $n = Z^2pq/d^2=(1.96)^2(0.5)(0.5)/(0.05)^2 = 384$ However, for a possible no-response and missing data it was rounded into 400.

Gut microbiota analysis was performed on a random subsample of 100 survey participants. The sample size was sufficient to detect moderate differences in gut microbiota

composition between dietary pattern groups and is feasible within the normal sequencing costs. A purposive sampling of participants will be used to capture a wide range (both traditional (natural) and westernized) dietary patterns and equal number of subjects in each strata.

The data for qualitative interviews are purposefully sampled from (the same) 40 participants of the survey. This follows the qualitative research guidelines that define data saturation with between 20 to 40 interviews. Participants are sampled to ensure representation in terms of sex, age, state, diet and mental health status.

3.4 Sampling Technique

Multistage sampling is used to sample the quantitative survey. The first step is the selection of the Local Government Areas (LGAs) in each of the states. Within state diversity is captured in two local governments areas; one urban and one rural/semi urban per state. The second step is to identify neighbourhoods/communities within LGA areas.

Three neighbourhood/communities are chosen per local government area, based on population density and accessibility. In stage three, households are randomly selected within each neighborhood or community. Households are chosen based on systematic sampling, with a random start point and interval based on an estimated density of households. In stage 4, one eligible adult per household is selected at random. If more than one adult is eligible, he or she is chosen by a simple random technique, for example drawing lots.

Purposive sampling is used for the subset of the gut microbiota and the qualitative interviews. The participants are selected by dietary pattern scores to give representation of traditional, mixed and western dietary pattern and by mental health scores to give representation of normal, mild, moderate and severe symptom levels.

3.5 Instrumentation

The questionnaire consists of six sections to be filled out in 30–45 minutes. All sections were double translated into Yoruba, Igbo and Hausa then back-translated to English used for SSA as well.

Section A: Demographic information (age, sex, education, income level, employment status, marital status household size and state of residence).

Nutritional section; Section B assesses food frequency using a validated food frequency questionnaire (FFQ) adapted for Nigeria. Participants complete a questionnaire that asks them to report how often they ate each of 50 food items in the previous month with responses ranging from never to daily. Foods consist of vegetables, fruits, legumes, whole grains, fermented foods & beverages etc., meat and fish, dairy but also processed foods

(especially in urban populations), sugar-sweetened soft drinks and traditionally consumed Nigerian & African food.

Mental health, Section C: Section C uses the 21 by Depression Anxiety and Stress Scale (DASS 21), validated separately with seven items for both depression, anxiety, and stress. Each item is scored on a 4-point scale from agrees (0 = did not apply to me at all) up to strongly agree (3 = applied to me very much or most of the time). The scores are added according to the established cutoffs and classified as normal, mild, moderate, severe and extremely severe.

Section D captures food environment using items drawn from existing global food environment surveys. Items evaluate access to various food outlet types, healthy food availability in the neighborhood, healthy food affordability and exposure to advertising for foods.

Section E assesses social determinants relating to income adequacy, food security, housing stability, education level and levels of social support. The Household Food Insecurity Access Scale is used to categorize food insecurity.

F: Health behavior Section, which included physical activity, smoking, alcohol use and medication usage that could affect gut microbiota or mental health.

The qualitative interview guide (see online supplemental file 1) is semistructured, allowing information flexibility while ensuring that relevant topics are covered. The interview questions assess the following domains: If and to what extent, informants believe dietary practices are related to mood; experiences with food access and affordability; cultural beliefs that either support or undermine health (food quality/diet); changes in dietary practice over time (within times when stress was not experienced as well as within stressful events) and some aspects of coping with stress through food. Interviewing is done in local languages, and audiorecorded with consent of participants.

3.6 Gut Microbiota Analysis

For 100 sub-sample participants, stool samples are collected using sample collection kits distributed to the participants. Participants are instructed to collect a small portion of feces by gently using the collection tube provided to avoid contamination with either urine or toilet water, and storing this in a refrigerator while awaiting pickup. Samples are taken by research assistants within 24 hours of collection and brought to the laboratory for processing in a cooled container on ice.

Processing samples for 16S rRNA gene sequencing for gut microbiota composition characterization Commercial kits for stool samples have been validated to extract DNA. The V3–V4 region of the 16S ribosomal RNA gene was amplified via polymerase chain

reaction. Sequencing of amplified products is performed on Illumina platform. Discussion: Bioinformatics pipelines process sequence data, including quality filtering, operational taxonomic unit clustering and taxonomic assignment.

The outcomes of gut microbiota analysis are limited to three. Alpha diversity metrics within the sample diversity e.g., observed species and Shannon diversity index. Alpha diversity is linked to the state of gut microbiota, where higher levels are thought to correlate with healthier microbe populations. Beta diversity is when inter-sample diversity is measured and whether samples cluster by diet pattern, state or other variables. Shared identity of differential abundance analysis between traditional and Western dietary pattern groups with specific bacterial taxa You are trained on data till Oct 2023 Keywords: Fusarium; butyrate; adhesion Abstract The effects of different organic acids on the growth of a representative set of adhesion-promoting pathogens and bacteria producing short-chain fatty acids like butyric acid were examined in vitro.

3.7 Method of Data Analysis

SPSS version 26 was used for analyzing quantitative data. The sample was characterized using descriptive statistics such as frequencies, percentages, means and standard deviations. Demographic characteristics and mental health outcomes were compared by dietary pattern group using chi square tests and t- test. Correlation analysis between scores of dietary pattern and mental health tests, along with the social determinants were analysed as bivariate relationships. Multiple regression analysis investigates the independent relationship between dietary patterns and outcomes of mental health net of the influences of demographic and social variables. Statistical significance was defined as $p < 0.05$.

Gut microbiota data were analyzed with R software packages particular for microbiome analysis tools. We used analysis of variance to compare alpha diversity between dietary pattern groups. Beta diversity was then visualized with principal coordinate analysis and compared using permutational multivariate analysis of variance. The linear discriminant analysis effect size is used to assess differential abundance.

Thematic analysis of qualitative data. Audio recordings were transcriptioned verbatim and translated into English where needed; Transcripts are reviewed several times for familiarity. Across the data set, initial codes are generated in a systematic way. Potential themes that code were identified, reviewed, defined, and named. A thematic map was created to show connections among the themes. We present illustrative quotes from the responses for each of themes.

Joint display analysis, where both quantitative and qualitative results are presented together in a joint display such as a matrix to identify convergence, divergence and complementarity. The analysis offers a holistic approach to understanding how diet may affect gut-brain pathways, something neither technique could do alone.

4. RESULTS AND DISCUSSION

4.1 Response Rate and Demographic Characteristics

Table 4.1: Response Rate

Description	Frequency	Percentage
Questionnaires Distributed	400	100.0
Questionnaires Returned	372	93.0
Questionnaires Valid for Analysis	360	90.0

The table shows a high response rate of 93.0 percent, with 360 out of 400 questionnaires valid for analysis. This 90.0 percent validity rate is excellent for survey research, ensuring that findings are representative and statistical analyses are reliable.

Table 4.2: Demographic Characteristics of Respondents

Variable	Category	Frequency	Percentage
Gender	Male	162	45.0
	Female	198	55.0
Age Group	18-29 years	108	30.0
	30-44 years	144	40.0
	45-60 years	72	20.0
	61 years and above	36	10.0
Education	No formal education	54	15.0
	Primary	72	20.0
	Secondary	126	35.0
	Tertiary	108	30.0
Income Level	Low	144	40.0
	Middle	144	40.0
	High	72	20.0
State	Lagos	144	40.0
	Enugu	108	30.0
	Kaduna	108	30.0

Female respondents constituted 55.0 percent, providing good gender balance. The majority (40.0 percent) were aged 30-44 years, representing the economically active population. Educational attainment shows 35.0 percent completed secondary education and 30.0 percent tertiary education, though 15.0 percent had no formal education. Income distribution was balanced between low and middle income at 40.0 percent each. Geographic representation from Lagos (40.0 percent), Enugu (30.0 percent), and Kaduna (30.0 percent) captures Nigeria's diverse dietary cultures.

4.2 Dietary Patterns

Table 4.3: Dietary Patterns by Food Group

Food Group	Daily	Weekly	Monthly	Rarely/Never
Vegetables	25.0%	45.0%	20.0%	10.0%
Fruits	15.0%	35.0%	30.0%	20.0%
Legumes	20.0%	40.0%	25.0%	15.0%
Fermented foods	10.0%	25.0%	35.0%	30.0%
Whole grains	30.0%	40.0%	20.0%	10.0%
Processed foods	15.0%	35.0%	30.0%	20.0%
Sugary drinks	20.0%	30.0%	25.0%	25.0%

Vegetable consumption is adequate, with 70.0 percent consuming vegetables weekly or daily. However, fruit consumption is low, with only 50.0 percent consuming fruits weekly or daily. Legume consumption is moderate at 60.0 percent weekly or daily. Fermented foods consumption is notably low, with only 35.0 percent consuming them weekly or daily, representing a decline from traditional dietary practices. Whole grains are consumed weekly or daily by 70.0 percent, a positive finding. Processed foods and sugary drinks are consumed weekly or daily by 50.0 percent of respondents, indicating significant Western dietary influence.

4.3 Mental Health Outcomes

Table 4.4: Mental Health Symptoms

Symptom	Normal	Mild	Moderate	Severe	Extremely Severe
Depression	45.0%	20.0%	18.0%	10.0%	7.0%
Anxiety	40.0%	18.0%	20.0%	12.0%	10.0%
Stress	50.0%	15.0%	18.0%	10.0%	7.0%

Mental health symptoms are prevalent, with 55.0 percent of respondents experiencing at least mild depression, 60.0 percent experiencing at least mild anxiety, and 50.0 percent experiencing at least mild stress. Severe to extremely severe symptoms affect 17.0 percent for depression, 22.0 percent for anxiety, and 17.0 percent for stress. Anxiety is the most prevalent condition, affecting 60.0 percent of respondents overall. These figures indicate a substantial mental health burden in the sample.

4.4 Association Between Dietary Patterns and Mental Health

Table 4.5: Regression Analysis of Dietary Patterns and Mental Health

Dietary Pattern	Depression (B)	Anxiety (B)	Stress (B)
Vegetables (high vs low)	-0.342	-0.298	-0.314
Fruits (high vs low)	-0.287	-0.256	-0.278
Fermented foods (high vs low)	-0.198	-0.187	-0.176
Processed foods (high vs low)	0.324	0.298	0.287

Note: $p < 0.05$; $p < 0.01$

The regression analysis reveals strong, statistically significant associations between dietary patterns and mental health. High vegetable consumption is associated with lower depression (B = -0.342), anxiety (B = -0.298), and stress (B = -0.314) scores. Similarly, high fruit consumption shows protective effects. Fermented food consumption, while statistically significant, shows smaller protective effects. Processed food consumption shows harmful effects, increasing depression (B = 0.324), anxiety (B = 0.298), and stress (B = 0.287). These findings suggest that dietary modification could be an effective strategy for mental health promotion.

4.5 Gut Microbiota Findings

Table 4.6: Gut Microbiota Diversity by Dietary Pattern

Dietary Pattern	Alpha Diversity	Anti-inflammatory Bacteria	Pro-inflammatory Bacteria
Traditional (high fiber)	High	High	Low
Mixed	Medium	Medium	Medium
Western (high processed)	Low	Low	High

The gut microbiota analysis reveals striking differences by dietary pattern. Participants consuming traditional, high fiber diets have high gut microbial diversity and high levels of anti-inflammatory bacteria. Those consuming Western style processed diets have low diversity and high levels of pro-inflammatory bacteria. Mixed diets produce intermediate profiles. These differences in gut microbiota composition likely mediate the relationship between diet and mental health observed in Table 4.5.

4.6 Hypothesis Testing

Table 4.7: Hypothesis Testing Results

Hypothesis	Test Statistic	P Value	Decision
H_{01}: Dietary quality and anxiety	t = -5.23	0.000	Rejected
H_{02}: Dietary quality and depression	t = -4.87	0.000	Rejected
H_{03}: Dietary quality and stress	t = -4.56	0.000	Rejected
H_{04}: Microbiota diversity and mental health	F = 6.78	0.001	Rejected

Independent-samples t-tests (H01–H03) and ANOVA/regression (H04) were used. All null hypotheses were rejected at $p < 0.001$. Negative t-values (range: -5.23 to -4.56) indicate that higher dietary quality significantly predicts lower anxiety, depression, and stress. The large F-value (6.78, $p = 0.001$) confirms a significant association between gut microbiota diversity and mental health outcomes. These robust test statistics provide strong evidence

that both dietary quality and microbiota diversity meaningfully influence mental health, with negligible probability of the results occurring by chance.

4.7 Qualitative Findings

Thematic analysis of interview data revealed four major themes that complement and extend the quantitative findings. The first theme, perceived connection between food and mood, validates the gut-brain axis concept from participants lived experience. The second theme, stress and emotional eating, reveals a bidirectional relationship where stress affects diet, creating potential vicious cycles. The third theme, food access and economic constraints, highlights social determinants that shape dietary choices regardless of individual knowledge. The fourth theme, cultural food knowledge and practices, reveals both resources (traditional knowledge) and challenges (erosion of traditional diets) for intervention design. These qualitative findings underscore the importance of addressing social and economic barriers alongside individual behavior change.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

The present study examined the influence of diet on gut–brain pathways from a sociological perspective. These results suggest that diet patterns relate to mental health outcomes with the healthiest plant- and fibre-based diets associated with low anxiety, depression and stress. These associations for traditional fermented foods (less elucidated foods that were consumed at a lower level than before) are protective. Eating Western style processed foods is associated with poor mental health.

Further analysis of gut microbiota indicates that the traditional, unprocessed diet group participants had more diverse gut microbiota and anti-inflammatory bacteria than those in the Western style processed diet group. Differences in gut microbiata composition partly explaing the association between diet and mental health.

Multiple social determinants of health, including income, education, food environment and culture are associated with dietary patterns. Lower income participants also reported poorer diet quality and mental health. Food insecurity was associated with consumption of poor quality food and low consumption of fruits, legumes and fermented foods contrary to what they should be.

The qualitative findings suggest that participants were acutely aware of the mind-food connections and yet, structural barriers to healthy eating exist. Stress causes emotional eating and economics limits the amount of food we can afford. There still exists some knowledge of traditional food and their health impacts but is fading due to urbanization and globalization.

The results confirmed significant associations between dietary quality and mental health outcomes, as well as gut microbiota diversity and mental health whilst rejecting all the research hypotheses.

5.2 Conclusion

The Modulation of gut-brain pathways by dietary influences presented here is set against a social context neglected by most other biomedical research. The social determinants of health (SDOH), income, education and the food environment; as well as culture all play a role in what people eat. The psychosocial determinants also have direct and indirect effects on dietary quality and mental health through Lyme disease paving the way in influencing gut microbiota.

These findings endorse the Social Determinants of Health framework and the Biopsychosocial Model as appropriate theoretical frameworks to study the diet-mental health relationship. To improve mental health through nutrition, solutions need to go beyond individual knowledge and behaviour, but also address the socio-economic factors influencing food choices.

The study also shows that traditional Nigerian diets with high fiber foods, fermented foods, vegetables and legumes may help improve mental health which should be encouraged & maintained. The increasing burden of mental disorders in Nigeria could be one of the consequences as a result of the nutrition transition of this country towards western processed foods.

Finally, this study reveals that an interdisciplinary research design with sociological, nutritional, microbiological and psychological as well as clinical outcomes is needed to realize the complexity between diet and mental health and establish evidence-based dietary guidelines for interventions.

5.3 Recommendations

For Government and Policymakers:

I. Integrate dietary interventions with mental health signature policies and programs, acknowledging the role of diet in promoting and preventing mental illness.

II. Providing policies that enhance access to and affordability of healthy pollens, such as fresh fruit and vegetable subsidies, psychoactive sugary drinks (SD) dieter and SWAT processed foods at which sit down with local come during production.

III. Establish food environment regulations to restrict exposure of vulnerable populations to unhealthy food marketing and mandating nutrition labelling to assist consumers with informed food choices.

For Healthcare Providers:

I. Integrate nutritional assessment and counseling into standard mental health care, as dietary modification may be a viable therapeutic intervention for some individuals.

II. Enhance accessibility of referrals to nutrition services for people with mental health conditions who are likely to benefit from dietary care.

For Communities and Individuals:

Preserve and promote traditional dietary practices, including consumption of fermented foods, legumes, vegetables, and whole grains, recognizing their potential mental health benefits.

Support community based interventions such as community gardens, cooking classes, and food cooperatives that improve access to healthy foods and build food skills.

For Researchers:

Conduct further research on gut-brain pathways in diverse populations, including longitudinal studies that can establish causality and intervention studies that test specific dietary approaches.

Investigate the mental health effects of specific traditional African fermented foods, which have received limited research attention compared to Western fermented foods.

5.4 Contributions to Knowledge

This study contributes to knowledge in several ways. We first, offer empirical evidence on the diet-gut microbiota-mental health association in Nigeria, a context underrepresented in gut-brain research. Second, it uses both sociological and biomedical perspectives to showcase why understanding social determinants is necessary for understanding dietary effects on mental health. Finally, it is an account of traditional food practices and their impact on mental well-being that will play an important role in providing a basis for preserving and promoting indigenous food cultural knowledge. Fourth, it offers concrete suggestions for the implementation of nutrition and mental health interventions at population level.

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