Magnesium Intake and Depression in U.S. Adults

by

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Abstract

Depression is a prevalent mental health disorder among adults in the United States. The link between nutrition and functional mental health has not been heavily explored when compared to other risk factors. Magnesium has an important role in certain neurotransmitter pathways and has been associated with mental health disorders including depression. The objectives of this study were to determine if there was an association between magnesium intake and depression in U.S. adults and if this association existed when stratified by sex and ethnicity. A cross-sectional study using secondary data from the 2017 – 2020 pre-pandemic National Health and Nutrition Examination Survey (NHANES) was performed. A bivariate and partial correlation was conducted with body mass index (BMI) as a covariate. Three depression questions from the PHQ-9 were used as the dependent variable for depression. Results showed a significant correlation between magnesium intake and depression for all three depression questions in the total sample, rho (5811) = -0.054, $p < .05$, rho (5811) = -0.047, $p < .05$, and rho (5811) = -0.034, $p < .05$, respectively. Further, there was a significant correlation between magnesium intake in males and depression question 1, rho (2820) = -0.062, $p < .05$, and magnesium intake in females for depression question 3, rho (2987) = -0.053, $p < .05$. Significance was also found for magnesium intake in Non-Hispanic Whites and depression questions 1 and 2, rho (1859) = -0.072, $p < .05$ and rho (1859) = -0.057, $p < .05$, respectively. Significance was also found for Other Race, rho (318) = -0.126, $p < .05$. These findings suggest that magnesium intake may be an important predictor of depression.

Keywords: depression, mental disorder, magnesium intake, adults, nutrition, National Health and Nutrition Examination Survey

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Introduction

Review of Literature

Globally, an estimated 280 million people have depression (World Health Organization [WHO], 2023). Around 16 million adults experience depression every year in the United States (Centers for Disease Control and Prevention [CDC], 2023). Depression, also known as major depressive disorder, is a common mental health disorder that affects how a person thinks, feels, and behaves (Torres, 2020). Depression is categorized based on its seriousness from mild, temporary episodes of sadness to severe, persistent depression, or clinical depression (Hall-Flavin, 2017). Depression can significantly impair the lives of an individual, hindering or limiting their ability to complete daily activities (Torres, 2020). There is a higher prevalence of depression among women (10.5%) compared to men (6.2%) (U.S. Department of Health and Human Services, 2022). Furthermore, Black and Hispanic individuals experience disproportionally greater rates of undiagnosed and untreated depression than White individuals (Blue Cross Blue Shield Association, 2022).

Risk factors for depression include genetic makeup, brain biochemistry, environmental factors, and other existing mental health disorders (Torres, 2020). While one or many factors may be involved, the exact cause is not deeply understood (Torres, 2020). One factor that has not been heavily explored in the literature is the role of nutrition in the development of depression. Consequently, the connection between nutrition and depression is not as widely known, particularly in comparison to the connection between nutritional deficiencies and physical illnesses (Grajek et al., 2022).

Current Treatment Options for Depression

Since depression is a crucial public health issue, several treatments have been used for management and recovery. Existing treatments in the acute phase of major depression disorder aim to help an individual reach recovery and return to a favorable level of functionality (Karrouri et al., 2021). Validated treatments for depression include pharmacotherapy, psychotherapy, somatic therapies, and combinations of medications (Karrouri et al., 2021).

Pharmacotherapy is a medication approach that includes classes of many different antidepressants (Karrouri et al., 2021). Serotonin reuptake inhibitors (SSRIs) are considered optimum antidepressants within this treatment option and the overall treatment of depression (Karrouri et al., 2021). The side effects of SSRI use include digestive and sexual issues along with anxious feelings, insomnia, and suicidal thoughts (Karrouri et al., 2021). Since no evidence has shown any class of antidepressant to be superior to SSRIs, they are generally the first line of treatment prescribed for individuals with major depression disorder (Karrouri et al., 2021).

The second class of antidepressant is tricyclic antidepressants (TCA) (Karrouri et al., 2021). Some TCAs can be just as efficient as SSRIs; however, their use is reserved for individuals with severe depression symptoms who require hospitalization (Karrouri et al., 2021). The side effects of some TCAs can be more severe than some SSRIs (Karrouri et al., 2021).

The third class of antidepressants is monoamine oxidase inhibitors (MAOIs) (Karrouri et al., 2021). This class of antidepressants is not typically used due to many harmful, potentially deadly side effects (Karrouri et al., 2021). Additionally, MAOIs

require diet restrictions and interact with many different drugs, making the prescription only for individuals who do not react well to other treatments (Karrouri et al., 2021). The pharmacological approach to treating depression has limitations since this approach predominantly targets monoaminergic neurotransmission systems (Karrouri et al., 2021). Therefore, few people reach full remission when taking antidepressant medications alone (Karrouri et al., 2021). Further research should investigate different mechanisms for antidepressant treatment (Karrouri et al., 2021).

Psychotherapy is the second most common approach for the treatment of depression (Karrouri et al., 2021). Cognitive behavioral therapy (CBT) and interpersonal therapy (IPT) are the two most recommended methods within depression-focused psychotherapy (Karrouri et al., 2021). CBT is a strategy that challenges and counters individuals' unsound beliefs and warped perspectives that might lead to depression (Karrouri et al., 2021). It includes therapies like problem-solving, acceptance and commitment, and schema (Karrouri et al., 2021). It is the first line of depression treatment for children and is highly recommended for adolescents with depression (Karrouri et al., 2021). CBT is a thoroughly researched and a well certified psychotherapeutic method (Karrouri et al., 2021). IPT aims to find the things that provoke depressive symptoms or episodes (Karrouri et al., 2021). This intervention is typically prescribed first for adults with mild to moderate major depression, and it has been accepted as an intervention for adolescents with depressive symptoms (Karrouri et al., 2021).

Somatic therapies examine the relationship between the mind and body (Karrouri et al., 2021). Electroconvulsive therapy (ECT), or when a person receives

electrical stimulation while under anesthesia, is considered the most effective somatic therapy (Karrouri et al., 2021). Generally, ECT is suggested for those with severe depression, suicidal risk, and who do not respond to other therapies or approaches (Karrouri et al., 2021).

Ultimately, the current treatment approaches offer effective ways to manage depression; however, prolonged efficiency of these approaches still poses a challenge (Karrouri et al., 2021). Pharmacotherapy, psychotherapy, and somatic treatments remain the primary evidence-based methods for treatment (Karrouri et al., 2021). Pharmacotherapy has the risk of adverse side effects, including suicidal thoughts, feelings of anxiousness, headaches, stomach issues, and insomnia, which can be counterproductive for some patients (Karrouri et al., 2019). Further research needs to be conducted so that other, less studied approaches can be validated.

Poor Nutrition and Depression

Nutrition plays a significant role in an individual's overall well-being. Having an optimal nutritional status is essential for the promotion of normal body function and helps prevent dysfunction and irregularities caused by various internal and external factors (Muscaritoli, 2021). Poor nutrition can impair the body's immune system, which serves as a line of defense against illness and disease (Muscaritoli, 2021). In addition, nutritional intake has been linked to the mental health functionality (Firth et al., 2020).

A research study conducted by Firth and colleagues (2020) found that poor nutrition is a possible causative factor in the experience of low mood and negative mental health. These findings revealed three concepts. The first concept, mood and

carbohydrates, indicated that the consumption of highly refined carbohydrates and sugars creates a high glycemic index and load (Firth et al., 2020). A high glycemic index may negatively affect psychological wellbeing and have an association with the incidence of depressive symptoms according to a longitudinal research study (Firth et al., 2020).

The second concept—diet, immune activation, and depression—demonstrated that high-caloric meals, which are also high in saturated fat, activate the immune system, which then induces an inflammatory response (Firth et al., 2020). Inflammation may have negative effects on brain health, including cognitive deficits and harm to the blood-brain barrier (Firth et al., 2020). Mental health disorders are also linked to heightened inflammation (Firth et al., 2020). Furthermore, several observational research studies showed that people with a high clinical depression score are more likely to have dietary inflammation (Firth et al., 2020). A Mediterranean diet promotes anti-inflammatory dietary patterns which can reduce inflammation in individuals (Firth et al., 2020). However, the relationship between diet, inflammation, and depression is complex in nature as confounding variables may play a role (Firth et al., 2020). For example, stress and genetics may interfere with the intervention of consuming anti-inflammatory foods (Firth et al., 2020).

The third concept was brain, gut microbiome, and mood. Under this discussion, Firth et al. (2020) presented evidence concerning how dietary patterns affect gut microbiome. The gut microbiome interacts with the various signaling pathways in the brain that have roles in regulating emotion in the human brain (Firth et al., 2020). A diet low in fiber and high in saturated fats, refined sugars, and

artificial sweeteners leads to an unhealthy gut microbiome, which can be a factor in depressive symptoms (Firth et al., 2020). However, no causative relationship has been established between microbes and human emotion (Firth et al., 2020). While this research is promising, the researchers concluded that it is important to remember that the causes of mental illness can be multifactorial (Firth et al., 2020).

Micronutrient Deficiency and Depression

Nutritional deficiency can contribute to the development of depression. Nutritional deficiency is defined as "an inadequate supply of essential nutrients (as vitamin and minerals) in the diet resulting in malnutrition or disease" (Merriam-Webster, 2023). A study conducted by Owczarek et al. (2022) examined the effects of nutritional deficiencies within the American population and its effects on depression. Folate, vitamin B12, vitamin B1, fiber, vitamin K, calcium, iron, zinc, copper, selenium, and magnesium were measured from National Health and Nutrition Examination Survey data (NHANES) (Owczarek et al., 2022). Analyses showed that only 13.9% and 27.5% of respondents met minimum fiber and magnesium intake requirements, respectively (Owczarek et al., 2022). Among the participants, individuals who were the most nutrient deprived had the highest depression severity (Owczarek et al., 2022). Fiber and magnesium measured individually were not associated with higher symptom severity (Owczarek et al., 2022). This research study was the first to consider patterns in dietary deficiencies when predicting mental health outcomes (Owczarek et al., 2022). The association between magnesium and depression should be further investigated due to magnesium's role in certain brain

functions and the low percentage of the adult population meeting recommended intake levels nationally.

Dietary Magnesium and Depression

Magnesium is an essential mineral (micronutrient) that plays an important role in maintaining the body's regulatory processes (Klemm, 2021). It is found in different foods including whole grains, legumes, nuts, and dark leafy green vegetables (U.S. Department of Health and Human Services, 2022). Magnesium assists in protein synthesis, bone development, and energy production (Klemm, 2021). It also regulates blood sugar, blood pressure, and muscle and nerve functions (Klemm, 2021).

Researchers have explored the impacts dietary magnesium has on neurological disorders and diseases. Magnesium plays a crucial role in various neurotransmitter systems, including serotonin, gamma-aminobutyric acid, and glutamate circuitry (Kirkland et al., 2018). Serotonin is a neurotransmitter that regulates several functions, particularly mood ("Serotonin: What is it, Function & Levels," 2022). Levels of serotonin decrease when there is a deficiency of magnesium in the body ("Serotonin: What is it, Function & Levels," 2022). Conversely, when there is an ample amount of magnesium in the body, serotonin activity increases ("Serotonin: What is it, Function & Levels," 2022).

Gamma-aminobutyric acid (GABA) is a neurotransmitter that reduces or slows down nerve transmissions (Kirkland et al., 2018). Magnesium is responsible for this process by activating a fragment of GABA receptors, which prevents an overactive brain (Kirkland et al., 2018). Glutamate is a neurotransmitter responsible for increasing neurotransmission in the brain (Kirkland et al., 2018). To prevent

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excess glutamate, magnesium blocks its actions to prevent "excitotoxicity" and cell death, which can contribute to depression or other mental disorders (Kirkland et al., 2018).

Current research has examined the relationship between magnesium intake and depression. One study conducted by Sun et al. (2018) investigated the relationship between dietary magnesium intake and the risk for depression. The study population consisted of 17,730 adults from the NHANES data from 2007-2014 (Sun a et al., 2018). Magnesium intake was assessed using 24-hour dietary recall, and depression was assessed using the Patient Health Questionnaire-9 (PHQ-9) (Sun et al., 2018). Logistic regression and cubic spline models were used for statistical analyses (Sun et al., 2018). The researchers identified an inverse association between dietary magnesium and depression (Sun et al., 2018). The subgroup analysis also demonstrated an inverse association between magnesium and depression among women but not among men, and the inverse association was found statistically significant among all age groups (Sun et al., 2018).

In another study conducted in Western Norway, Felice et al. (2009) sought to investigate the association between magnesium intake and depression and anxiety in a sample of male and female adults. Anxiety and depression were self-reported using the Hospital Anxiety and Depression Scale, and magnesium intake was assessed using a questionnaire (Felice et al., 2009). The results demonstrated an inverse association between standardized energy-adjusted magnesium intake and standardized depression scores (Felice et al., 2009).

Gaps in Research

The eight dimensions of wellness are emotional, spiritual, intellectual, physical, environmental, financial, occupational, and social (Stoewen, 2017). A healthy, functional mental space and adequate nutritional intake support the development and growth of each dimension. Current research has focused on the connection between multiple nutrient deficiencies at one given time and mental health disorders. There is no substantial research on individual nutrients, like magnesium, and its association to depression in a representative sample. Additionally, there is a lack of research using data collected from the United States population. Depression is complex in nature and often requires an integrated or holistic approach for treatment and management. Investigating the impact of dietary magnesium intake on depression can provide insight into preventative measures along with approaches for treatment, such as medical nutrition therapy and nutritional psychiatry. It also can provide a deeper understanding of the complexities of how certain nutrients influence neurological pathways.

Purpose of the Study

The purpose of this study was to explore the relationship between magnesium intake and depression in U.S. adults aged 18 to 64. This study also explored the association between magnesium intake and depression separated by gender and race/ethnicity variables. The results of this study may inform healthcare professionals about how to provide comprehensive care to patients and aid in the development of new approaches for depression treatment. Any differences observed in sex and

race/ethnicity can serve as the framework for further research into specific populations.

Research Questions

The following research questions guided this study:

1. Is there an association between magnesium intake and depression? (At least one of the nine item depression survey questions)

2. Is there an association between magnesium intake and depression, stratified by sex? (At least one of the nine-item depression survey questions)

3. Is there an association between magnesium intake and depression, stratified by race/ethnicity? (At least one of the nine item depression survey questions)

Hypotheses

It was hypothesized that there would be an inverse association between magnesium intake and at least one depression question. It was hypothesized that there would be an inverse association between magnesium intake in females and at least one of depression question. It was hypothesized that there would be an association between magnesium intake and the depression question that differentiated by race/ethnicity.

Method

Design

   A cross sectional design was used to explore the association between magnesium intake and depression. Secondary data from the NHANES were analyzed. NHANES is the most comprehensive survey designed to assess the health and nutritional status of adults and children in the United States (CDC, 2021). The data collected from the survey can be used to understand risk factors and the prevalence of diseases as well as evaluate the nutritional status and any association with health promotion and disease prevention in the United States population (CDC, 2021). The findings can also be used to serve as the basis for policies and health promotion/disease prevention programs (CDC, 2021). Due to the COVID-19 pandemic, the data collected from 2019 to March 2020 were combined with data from 2017 to 2018 to form a complete nationally representative sample.

Procedures

   The NHANES is a combination survey that includes health interviews, physical examinations, and laboratory tests to obtain different measurements (CDC, 2021). Households in the United States were sent invitation letters and completed a questionnaire on the phone or online to determine eligibility (CDC, 2021). Participants who met the eligibility criteria were selected, and a health interview was scheduled. The health interviews were conducted by phone, and the examinations and measurements were performed by medically trained staff who traveled in mobile centers to NHANES locations throughout the country (CDC, 2021). The interview questions collected data on participants' demographics, socioeconomic statuses,

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dietary intake and patterns, and mental health using a series of questionnaires (CDC, 2021). The laboratory tests included infectious diseases, kidney function, glucose, cholesterol, and nutritional status tests (CDC, 2021). For this research, participants' two-day magnesium intake and depression scores were examined.

Participants

The NHANES collected data from a sample of 15,560 children and adults. In this study, data from adults aged 18 to 64 were analyzed (N=5,811). This age group was targeted due the prevalence of depression in adults. The second research question analyzed gender differences due to the higher prevalence of depression in women. Race/ethnicity was analyzed due to the disparities in depression prevalence in Black and Brown communities.

Independent Variable and Dependent Variable

The independent variable was magnesium intake, and the dependent variable was a participant's depression score. Magnesium intake was assessed using the 24-hour recall method, and the two-day intake was used and reported in milligrams. Depression was assessed using the PHQ-9 (CDC, 2021). The PHQ-9 determines the frequency of depressive symptoms over the past two weeks (CDC, 2021). Response options to each question ranged from 0 ("not at all") to 3 ("nearly every day") (CDC, 2021). This study used three key questions from the PHQ-9 to determine depression scores: (1) "having little interest in doing things," (2) "feeling down, depressed, or hopeless," and (3) "thoughts you would be better off dead" (CDC, 2021). The selected questions were most associated with the definition of depression in this specific study.

Data Analysis

Both the independent and dependent variables were continuous. A non-parametric correlation (Spearman's correlation) was used to measure the strength of the relationship between the variables. A bivariate correlation and partial correlation were performed on the data. Body mass index (BMI) was used as a covariate. Each depression question was analyzed individually with magnesium intake to determine a relationship. The data were filtered from a created syntax to not include any participants who had missing data for the variables being examined. The statistical analyses were conducted on unweighted data using IBM's Statistical Package for Social Sciences software (SPSS) version 29.0.0.0. G*Power was used to determine the sample size. From the calculations, 776 participants were needed to support the correlation analysis. The alpha level to determine statistical significance was .05. The subgroup analyses for research questions 2 and 3 were conducted using a split file feature for male and female and ethnicity. After the file was split into the subgroups, the correlations were performed.

<center>**Results**</center>

Participant Demographics

      The NHANES 2017-March 2020 pre-pandemic data consisted of 15,560 participants. The analyzed data consisted of 5,811 participants who were adults aged 18 to 64. Of the sample, 2,822 (48.6%) were males, and 2,989 (51.4%) were females. Of the sample, 717 (12.3%) were Mexican American; 589 (10.1%) were Other Hispanic; 1,861 (32.0%) were Non-Hispanic White; 1,617 (27.8%) were Non-Hispanic Black; 707 (12.2%) were Non-Hispanic Asian; and 320 (5.5%) were Other Race-Including Multi-Racial. The average BMI of the sample was 29.33, and the average magnesium intake was 293.66 mg. The average magnesium intake for males was 330.26 mg. The average magnesium intake for females was 259.10 mg. For the general sample, the average depression scores for questions 1, 2, and 3 were 0.38, 0.37, and .05, respectively. For males, the average depression scores for questions 1, 2, and 3 were 0.34, 0.32, and .06, respectively. For females, the average depression scores for questions 1, 2, and 3 were 0.42, 0.43, and 0.05, respectively. See Tables 1 and 2 in the Appendices.

Major Findings

      This research examined the association between magnesium intake (independent variable) and depression scores (dependent variable). The sample data were not normally distributed according to normality tests; therefore, a Spearman's correlation analysis was performed. Results from the bivariate and partial correlations are shown in Tables 3 to 7 (see Appendices). BMI served as a covariate in the partial correlation analysis.

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The first research question was, "Is there an association between magnesium intake and depression?" Each correlation output showed a weak negative correlation since all rho coefficient values were less than 0.3, signaling a negative direction. We observed statistical significance ($p < .05$) in all three depression questions for U.S. adults, which indicates a significant relationship between magnesium intake and depression. Significance was found for depression question 1, rho (5811) = -0.054, $p < .05$; depression question 2, rho (5811) = -0.047, $p < .05$; and depression question 3, rho (5811) = -0.034, $p < .05$. These findings suggest that when magnesium intake was low, the depression score was high for each of the depressive symptoms. See Table 3 in the Appendices.

The second research question asked, "Is there an association between magnesium intake and depression, stratified by sex?" Weak negative correlations were observed in both males and females for all three depression questions, but one correlation from each sex indicated statistical significance. In males, depression question 1, "having little interest in doing things," showed statistical significance to magnesium intake, rho (2820) = -0.062, $p < .05$. In females, depression question 3, "thoughts you would be better off dead," showed statistical significance to magnesium intake, rho (2987) = -0.053, $p < .05$. These findings indicate that when magnesium intake was low, the depression scores were high for males and females. See Tables 4 and 5 the Appendices.

The third research question asked, "Is there an association between magnesium intake and depression, stratified by ethnicity?" A weak negative correlation was found among each race/ethnicity. Only the tests for magnesium intake

in Non-Hispanic White and Other Race Including Multi-Racial and depression were found to have statistical significance. For Non-Hispanic Whites, depression question 1, "having little interest in doing things," showed statistical significance to magnesium intake, rho (1859) = -0.072, $p < .05$. There was also a statistically significant association between this ethnic group and magnesium intake for depression question 2, "feeling down, depressed, or hopeless," rho (1859) = -0.057, $p < .05$. For Other Race Including Multi-Racial, statistical significance was found for both depression question 1, "having little interest in doing things," and depression question 3, "thought you would be better off dead," and magnesium intake, rho (318) = -0.126, $p < .05$. These findings indicate that when magnesium intake was low in these ethnic groups, depression scores were high. See Tables 6 and 7 in the Appendices.

Discussion

Summary of Major Findings

This study investigated if there was an association between dietary magnesium intake and self-reported depressive symptoms. Additionally, this study investigated if there was an association between magnesium intake and depression after stratification by gender and ethnicity. Overall, we observed a significant negative association between magnesium intake and depression for research question 1 for depression questions 1, 2, and 3 when analyzing the total sample. The correlations observed in the general sample were considered very weak due to the correlation coefficient being less than 0.3, even when we found a significant association.

For research question 1, the study results supported previous research findings. For instance, Sun and colleagues (2018) reported an inverse association between magnesium and depression when performing a logistic regression for an adult sample. After adjusting for BMI in this study, the correlation strength for all the three questions was attenuated, but the p-values were still statistically significant. This finding suggests that magnesium intake may be an important predictor of depression in adults aged 18 to 64. The findings in this study support our hypothesis that there is an association between magnesium intake and at least one depression question.

We also found significant associations between magnesium intake and depression question 1 in males and depression question 3 in females when answering research question 2. Overall, females had a lower magnesium intake than men and

higher depression scores on average. Previous research noted an inverse association between magnesium intake and risk of depression that was statistically significant among women but not men (Sun et al., 2018). However, our study showed at least one of the depression questions for both men and women were negatively associated with magnesium intake. This finding might have resulted from our sample generally having lower magnesium intake than recommended. Our hypothesis that only females would have an inverse association between magnesium intake and at least one depression question was not supported by the findings. Therefore, promotion of optimal magnesium intake might benefit both males and females.

When answering research question 3, we only found a significant correlation between magnesium and depression for non-Hispanic Whites and Other Race-Including Multiracial. For non-Hispanic Whites, there was significance for depression questions 1 and 2. For Other Race-Including Multiracial, there was significance for depression questions 1 and 3. The sample was predominantly Non-Hispanic White, and Other Race was the smallest percentage of the sample. Not having an equal number of participants in each race/ethnicity might have contributed to these findings. Previous research does not support significant correlations for only these two ethnicities alone (Sun et al., 2018; Tarleton & Littenberg, 2015). Our hypothesis that there would be an association of magnesium between magnesium intake and at least one depression question that differentiated between race/ethnicity is supported by the findings in this study.

Public Health Implications

Increasing Magnesium Intake

The recommended magnesium intake for U.S. adults 18 to 64 ranges from 310 mg to 420 mg, which varies depending on sex and gender (U.S. Department of Health and Human Services, 2022). The average magnesium intake in our sample was 293.66 mg. Non-Hispanic Black women and Other Race-Including Multiracial women consumed the lowest amount of magnesium at 236.39 mg and 229.65 mg, respectively.

The intake recommendations for magnesium are presented in the Dietary Reference Intakes (DRIs) created by the Food and Nutrition Board (FNB) at the Institute of Medicine of the National Academies (U.S. Department of Health and Human Services, 2022). DRI is the general term for a set of reference values used to plan and evaluate the nutritional intake of healthy individuals (U.S. Department of Health and Human Services, 2022). One reference value is the Recommended Dietary Allowance (RDA). The RDAs represent the daily level of intake that is satisfactory to meet the nutritional requirements of nearly all (97% to 98%) healthy individuals (U.S. Department of Health and Human Services, 2022). The findings of this study indicate that U.S. adults should increase magnesium intake to meet the recommendations to prevent deficiency.

Magnesium Supplementation

The results of this study indicated a negative correlation between magnesium intake and self-reported depression, indicating that when magnesium intake was low, the depression score was high. Sufficient sources of dietary magnesium can be found

in whole grains, legumes, nuts, and dark leafy green vegetables. It is always best to get magnesium from food sources; however, supplementation is available for individuals who cannot meet the recommendations from food alone (U.S. Department of Health and Human Services, 2022).

Furthermore, magnesium supplementation has been shown to help treat depression (Tarleton et al., 2017). One research study conducted by Tarleton and colleagues (2017) examined the role magnesium supplementation has in depressive symptom management. This study's main objective was to test whether over-the-counter magnesium chloride supplementation could improve any symptoms of depression in adults (Tarleton et al., 2017). The intervention consisted of a six-week active treatment of 248 mg of magnesium daily and six weeks of no supplementation (Tarleton et al., 2017). The results showed that magnesium consumption for the six weeks had a significant net improvement in depression scores regardless of age, gender, or use of anti-depressants (Tarleton et al., 2017). It can be concluded that magnesium supplementation may be an effective intervention for mild to moderate depression in adults.

Nutritional Psychiatry & Future Research

Nutritional psychiatry is a new field of study examining the connection between nutrition and mental health (Adan et al., 2019). It uses diet and nutritional supplements to treat different mental health conditions (Adan et al., 2019). Several research studies have reported a link between diet and mental well-being (Firth et al., 2020; Owczarek et al.,2022). However, since this field of research is just emerging, the findings lack the consistency and quality needed that would drive public health

recommendations and medical practice (Jacka, 2017). More research needs to be conducted to establish the connection between different nutrients and mental health conditions. Moreover, further research must be conducted to examine the role dietary nutrients can have in the management and treatment of mental health conditions. This study identified that U.S. adults do not meet recommended magnesium intake levels, which might have contributed to the depression high scores in the sample. This finding indicates the necessity for future research to explore the link between magnesium and depression and to examine subgroups to determine the best treatment options.

Study Limitations and Strength

This study utilized secondary data from the NHANES, which resulted in several limitations. The data collection method included online and telephone surveys, so the results were likely impacted by self-report bias. Participants who answered the depression questionnaire over the telephone could have felt pressured to provide socially acceptable answers or answer in the way the interviewer would like to hear, leading to self-report bias. Recall bias was another limitation. Participants self-reported magnesium intake over a 24-hour timespan and depressive symptoms over two weeks, which might had led some participants not being able to remember or accurately recall information. This factor could have also resulted in underreporting. The 24-hour recall method was also a limitation since this method might not have captured individuals' typical diet.

Cultural stigma might have been a limitation resulting in dishonest or inaccurate answers due to the nature of the depressive symptom questions.

Participants might not have felt comfortable responding truthfully due to the existing stigma with mental health disorders. This limitation might have contributed to skewed answers. Further, this study only used three questions from the PHQ-9 instead of the total score to indicate depression. Participants' total depression scores might have yielded stronger or weaker results between depression and magnesium intake. The race/ethnicity was not weighted, which could have impacted the results. This limitation might have occurred due to the data being filtered to represent a population of individuals aged 18 to 64 who had no missing data for any of the variables being examined. Finally, this was a cross-sectional study; thus, causation cannot be presumed.

A strength of this study was the selection of the participants from a nationally representative sample. Therefore, the findings of this research can be generalized to the adult population age 18 to 64 in the United States. The PHQ-9 is a validated depression screen that incorporates the *Diagnostic and Statistical Manual of Mental Disorders* depression diagnostic criteria into the questions. The study also adjusted for BMI, which is another major predictor of depression. Notably, the adjusted correlation coefficients reported in this study specify the independent effect of magnesium intake on depression.

Conclusion

To conclude, this study found a correlation between magnesium intake and depression. Future research should focus on investigating gender and each ethnicity individually to further explore any differences and understand the relationship to promote best treatment practices. Additionally, the study population was deficient in

magnesium, so a promotion of optimal magnesium intake in U.S. adults could be

beneficial. Furthermore, magnesium rich foods and magnesium supplements may be

helpful as an intervention for depression symptoms. Lastly, more research is needed

to support nutritional psychiatry as an established treatment for mental health

disorders.

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Table 1

Demographic/Informational Table (n=5,811)

Sample Characteristics	N	Percentage	Average Mg Intake
Total	5,811	100%	293.66 mg
Male	2,822	48.6%	330.26 mg
Female	2,989	51.4%	259.10 mg
Mexican American	717	12.3%	331.41 mg
Other Hispanic	589	10.1%	312.02 mg
Non-Hispanic White	1,861	32.0%	296.86 mg
Non-Hispanic Black	1,617	27.8%	260.22 mg
Non-Hispanic Asian	707	12.2%	312.75 mg
Other Race	320	5.5%	283.64 mg

Table 2

Mean Depression Scores

Sample	Depression Question 1	Depression Question 2	Depression Question 3
Total	0.38	0.37	0.05
Male	0.34	0.32	0.06
Female	0.42	0.43	0.05
Non-Hispanic White	0.39	0.40	0.05
Other Race	0.56	0.58	0.11

Note: Question 1: "having little interest in doing things" Question 2:" feeling down, depressed, or hopeless Question 3: "thoughts you would be better off dead"

Table 3

Correlation between Magnesium Intake and Depression Questions for the Total

Sample (n=5,811)

| | Magnesium intake | | | |
| | Unadjusted | | Adjusted for BMI | |
Depression	rho	p-value	rho	p-value
Having little interest in doing things	-0.058	< 0.001	-0.054	< 0.001
Feeling down, depressed, or hopeless	-0.05	< 0.001	-0.047	< 0.001
Thoughts you would be better off dead	-0.036	0.007	-0.034	0.01

Table 4

Correlation between Magnesium Intake and Depression Questions for Males

(n=2,822)

| | Magnesium intake | | | |
| | Unadjusted | | Adjusted for BMI | |
Depression	rho	p-value	rho	p-value
Having little interest in doing things	-0.064	< 0.001	-0.062	0.001
Feeling down, depressed, or hopeless	-0.035	0.063	-0.034	0.074
Thoughts you would be better off dead	-0.011	0.572	-0.01	0.606

Table 5

Correlation between Magnesium Intake and Depression Questions for Females

(n=2,989)

| | Magnesium intake | | | |
| Depression | Unadjusted | | Adjusted for BMI | |
	rho	p-value	rho	p-value
Having little interest in doing things	-0.021	0.248	-0.014	0.439
Feeling down, depressed, or hopeless	-0.029	0.111	-0.024	0.195
Thoughts you would be better off dead	-0.055	0.002	-0.053	0.004

Table 6

Correlation between Magnesium Intake and Depression Questions for Non-Hispanic

Whites (n=1,861)

| | Magnesium intake | | | |
| | Unadjusted | | Adjusted for BMI | |
Depression	rho	p-value	rho	p-value
Having little interest in doing things	-0.077	<.001	-0.072	0.002
Feeling down, depressed, or hopeless	-0.065	0.005	-0.057	0.014
Thoughts you would be better off dead	-0.024	0.292	-0.021	0.361

Table 7

Correlation between Magnesium Intake and Depression Questions for Other Race –

Including Multiracial (n=320)

| | Magnesium intake | | | |
| | Unadjusted | | Adjusted for BMI | |
Depression	rho	p-value	rho	p-value
Having little interest in doing things	-0.127	0.023	-0.126	0.025
Feeling down, depressed, or hopeless	-0.109	0.052	-0.109	0.053
Thoughts you would be better off dead	-0.124	0.027	-0.126	0.024