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# Nutritional and Socioeconomic Disparities in Gastrointestinal Health: An Analysis of NHANES Data on Diet, Food Allergies, Asthma and Access to Care

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## Keywords

Gastrointestinal diseases, Cancer, Asthma, Nutrition, Food.

## Introduction

Gastrointestinal (GI) diseases, such as colorectal cancer (CRC), inflammatory bowel disease (IBD), and irritable bowel syndrome (IBS), disproportionately affect individuals from various racial, socioeconomic, and regional backgrounds. Despite advancements in medical care, significant disparities persist in disease prevalence, access to screening, and treatment outcomes [1,2]. These disparities are often influenced by broader social determinants of health, including access to nutrition, income, education, and geographic location [3,4]. Understanding how these factors contribute to GI health disparities is crucial for developing targeted interventions to bridge gaps in care.

Nutrition plays a vital role in the prevention and management of GI diseases. Diets rich in fruits, vegetables, and fiber have been shown to reduce the risk of CRC [5], whereas food insecurity and unhealthy eating patterns contribute to increased disease burden and poorer outcomes in IBD and IBS [6,7]. However, access to healthy food is not equally distributed across populations. Individuals and communities from low-income or racially marginalized backgrounds often face challenges in adopting and maintaining healthy eating habits due to barriers such as food deserts, limited healthcare access, and financial constraints [8,9]. Additionally, populations with restricted access to preventive care and nutritional education are more likely to experience obesity—a major risk factor for GI disorders—further exacerbating health disparities [10].

Studies have identified a relationship between allergies and IBS, with evidence suggesting that individuals with allergies tend to experience more severe IBS symptoms. In particular, food allergies have been shown to play a critical role in the pathogenesis of IBS [11]. This literature review examines the intersection of GI health disparities, nutrition, and social determinants by synthesizing data from national databases, namely the **National Health and Nutrition Examination Survey (NHANES)** [3,6,8]. The objective of this review is to explore the extent to which nutrition can mitigate disparities in GI disease outcomes by analyzing patterns of food security, dietary interventions, and regional healthcare inequalities. Ultimately, understanding these relationships can inform public health initiatives and legislative efforts to promote more equitable treatment for vulnerable populations.

The **Fecal Incontinence Severity Index (FISI)** was developed by the **American Society of Colon and Rectal Surgeons (ASCRS)** to assess the impact of fecal incontinence (FI) on a patient's quality of life [12]. FI can serve as an indicator of disease activity in IBD [13]. The prevalence of FI in patients with IBD ranges from **12.7% to 76%** [12]. Although research in this area is limited, available evidence suggests that FI is associated with increased disease activity in IBD. Consequently, individuals reporting FI may have underlying, undiagnosed, or evolving IBD, particularly when other symptoms are present [14].

## Methods

The data was taken from the publicly available NHANES (National Health and Nutrition Examination Survey) database which is collected by the CDC. The data is a cross sectional representation of the American population, including extensive data on demographics, pre-existing health conditions, dietary intake, lifestyle choices (like smoking) and socioeconomic data.

### Steps:

Using the NHANES datasets (2009-2010), merged the DEMO_F Data: Demographics, Income (INQ_F), Bowel Health (BHQ_F), Diet Behavior & Nutrition (DBQ_F), Food Security (FSQ_F), Health Insurance (HIQ_F), Medical Conditions (MCQ_F), Smoking - Cigarette Use (SMQ_F), and Weight History (WHQ_F) datasets to be able to explore relationships between the socioeconomic, racial and regional factors and GI health/diseases. The merging was possible through the common identifier column: SEQN - Respondent sequence number.

R Code is included for replication. No comments.

## Results

### Exploratory Analysis

Comparing dietary behaviors and bowel health across socioeconomic status (Using Ratio of family income to poverty).

### Relationship between consumption of a healthy diet – DBQ700 rated excellent to fair and INDFMPIR–Ratio of family income to poverty

A Kruskal-Wallis rank sum test was performed to compare the distribution of the continuous variable INDFMPIR across the six categories of the variable DBQ700. The Kruskal-Wallis test is appropriate when comparing more than two independent groups on a continuous outcome, especially when the data does not follow a normal distribution.

Test Statistic (Chi-squared): 207.89
Degrees of Freedom (df): 5
p-value: < 0.0001

The results indicate a statistically significant difference in the distribution of Family income levels to poverty (an SES index) between the different levels of Consumption of a healthy diet ($p < 0.001$).

Following the Kruskal-Wallis test for differences in SES across the levels of Diet, post-hoc pairwise comparisons were conducted using Dunn's test to identify specific group differences. The results indicate significant differences in income level between several categories of consumption of a healthy diet.

"Don't know" vs "Excellent":
Z = -2.08, p = 0.0187: The "Don't know" group is associated with lower values of SES compared to the "Excellent" group. This suggests that individuals in the "Don't know" category have a lower socioeconomic status compared to those in the "Excellent" category.

"Excellent" vs "Fair":
Z = 8.37, p < 2.8e-17: The "Excellent" group has higher values of SES than the "Fair" group. This finding indicates that individuals in the "Excellent" diet category tend to have a higher socioeconomic status than those in the "Fair" category.

"Good" vs "Poor":
Z = 6.24, p < 2.18e-10: The "Good" group has higher values of INDFMPIR compared to the "Poor" group. This suggests that individuals in the "Good" category have higher socioeconomic status compared to those in the "Poor" category.

"Fair" vs "Very good":
Z = -11.49, p < 7.59e-31: The "Fair" group has lower values of INDFMPIR compared to the "Very good" group. This finding highlights that individuals in the "Fair" category tend to have a lower socioeconomic status than those in the "Very good" category.

## Summary

Lower INDFMPIR values are associated with individuals in the "Don't know", "Fair", and "Poor" categories.
Higher INDFMPIR values are associated with individuals in the "Excellent", "Good", and "Very good" categories.

Higher SES is associated with consumption of a healthy diet.

## Relationship between racial classification and FISI score

The FISI score was calculated from BHQ010 – BHQ040 In BHQ_f Data (Bowel Health)

The Kruskal-Wallis rank sum test was conducted to examine if there are significant differences in FISI (Fecal Incontinence Severity Index) across different races and ethnicity– RIDRETH1.

The test results were as follows:
Chi-squared = 9.7834
Degrees of Freedom (df) = 4
p-value = 0.04424:

The result suggests that there are significant differences in FISI across the levels of RIDRETH1, indicating that the categorical variable RIDRETH1 is associated with variations in the continuous variable FISI.

## Post hoc analysis with dunn test

Mexican Americans and Non-Hispanic Blacks have significantly different FISI scores, as shown by the Z-scores (2.23) and significant p-value (0.0127). This showed that Mexican Americans had significantly higher FISI scores compared to Non-Hispanic Blacks.

Non-Hispanic Black populations also differ significantly from Other Hispanic groups in terms of FISI scores (Z = 2.16, p = 0.00944). This showed that non-Hispanic blacks had significantly higher FISI scores compared to Other Hispanic groups.

Other Hispanic and Other race - including multi-racial groups are also significantly different in terms of their FISI scores (Z = 2.35, p = 0.0154). This showed that Other Hispanic had significantly higher FISI scores compared to other race - including multi-racial groups.

Ethnic groups like Non-Hispanic White and Other race show no significant differences in FISI scores,

## Descriptives and Charts

**Descriptive Statistics for Age**

| vars | n | mean | SD | median | trimmed | mad | min | max | range |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6059 | 49.48902 | 17.84236 | 49 | 49.192 | 22.239 | 20 | 80 | 60 |

**Chi-Square Test Results: Gender vs Other Variables**

| Variable1 | Variable2 | Chi_Square_Statistic | P_Value | Degrees_of_Freedom |
|---|---|---|---|---|
| Gender | Educational Attainment | 21.574376 | 0.001445736 | 6 |
| Gender | Race | 4.550203 | 0.336636168 | 4 |

## Logistic Regression

## Factors predicting having food allergies in participants (Yes|No)

**Step 1:** Trying to Identify significant variables are associated with the outcome variable – presence or absence of allergies

## Relationship between presence or absence of food allergies and age groups

**Age groups were categorized into:**
**Young Adults:** 19-29 years (This was the youngest age group in the dataset)
**Middle-Aged Adults:** 30-49 years
**Older Adults:** 50-79 years
A Chi-square test was conducted to examine the association between age group (Young Adults, Middle-Aged Adults, and Older Adults) and self-reported allergies (DBQ920).
Pearson's Chi-squared test
data: age_allergy_table
X-squared = 0.25602, df = 2, p-value = 0.8798

**Key Findings:**
The test yielded a Chi-square statistic ($X^2$) of 0.256 with 2 degrees of freedom.
The p-value was 0.8798, which is well above the standard significance threshold of 0.05.

**Interpretation:**
There was no statistically significant association between age group and the presence or absence of allergies.
This suggests that in the sample, age does not appear to be a major factor influencing reported allergies.

## Analysis without categorizing the age variable

Wilcoxon rank sum test with continuity correction
data: RIDAGEYR by DBQ920
W = 1585824, p-value = 0.8512
alternative hypothesis: true location shift is not equal to 0
No association, results was consistent

## Relationship between weight and food allergy statuses

Graphical representation, the uniform distribution of the box plot suggested a likely non-association
Wilcoxon rank sum test with continuity correction
data: WHD020 by DBQ920
W = 1612796, p-value = 0.3346
alternative hypothesis: true location shift is not equal to 0

The Wilcoxon rank sum test (also known as the Mann-Whitney U test) was performed to assess whether there is a significant difference in weight (WHD020) between individuals with food allergies (DBQ920) and those without.

- Test Statistic (W): 1,612,796
- p-value: 0.3346

Interpretation:

- The p-value of 0.3346 > 0.05, indicating that there is no

- statistically significant difference in the distribution of weight between individuals with and without food allergies.
- This suggests that food allergy status does not significantly affect weight in the NHANES sample.

This result indicates that weight (WHD020) is not strongly associated with the presence or absence of food allergies in this dataset, based on the statistical analysis conducted.

### Relationship between ethnicity and food allergies

Pearson's Chi-squared test
data: contingency_table
X-squared = 26.83, df = 4, p-value = 2.152e-05

A Pearson's Chi-squared test was conducted to evaluate the relationship between race/ethnicity (RIDRETH1) and the presence or absence of food allergies (DBQ920). The results showed a statistically significant association between race/ethnicity and food allergies (X-squared = 26.83, df = 4, p-value = 2.152e-05).

This suggests that food allergy prevalence varies across different racial/ethnic groups in the studied population. Given the low p-value (<0.05), the null hypothesis of no association is rejected, indicating that race/ethnicity may be an important factor influencing the occurrence of food allergies.

Post hoc analysis
Pairwise comparisons using Pairwise comparison of proportions
data: contingency_table

### Contingency Table

| Group | Mexican American | Other Hispanic | Non-Hispanic White | Non-Hispanic Black | Other race +multiracial |
|---|---|---|---|---|---|
| Other Hispanic | 0.00015 | - | - | - | - |
| Non-Hispanic White | 0.08981 | 0.06947 | - | - | - |
| Non-Hispanic Black | 0.00019 | 1.00000 | 0.11566 | - | - |
| Other race - including multiracial | 0.24682 | 1.00000 | 1.00000 | 1.000000 | - |

P value adjustment method: bonferroni

The pairwise comparison of proportions was performed to further explore the relationship between race/ethnicity (RIDRETH1) and the presence of food allergies (DBQ920) following the Chi-squared test. This analysis specifically assessed the differences in the prevalence of food allergies between different racial and ethnic groups, with Bonferroni correction applied to adjust for multiple comparisons.

Here are the key findings from the pairwise comparisons:
Mexican American vs. Other Hispanic: A statistically significant difference was observed in the prevalence of food allergies (p = 0.00015), suggesting that food allergies are significantly more prevalent in one group compared to the other.

Mexican American vs. Non-Hispanic White: No significant difference was found (p = 0.08981), indicating that the prevalence of food allergies does not differ significantly between these two groups after adjusting for multiple comparisons.

Mexican American vs. Non-Hispanic Black: A statistically significant difference was found (p = 0.00019), indicating that food allergies are more common in one of these two groups.

Mexican American vs. Other Race (including multi-racial): No significant difference was found (p = 0.24682).

Other Hispanic vs. Non-Hispanic White: A borderline significant difference was observed (p = 0.06947), but it was not statistically significant after the Bonferroni correction.

Non-Hispanic Black vs. Other race (including multi-racial): No significant difference was found (p = 1.00000).
Overall, this analysis suggests that Mexican Americans and Non-Hispanic Blacks may have a significantly different prevalence of food allergies compared to certain other ethnic groups, but no significant differences were observed between several other pairings. The use of the Bonferroni adjustment ensures that these findings are less likely to be due to chance due to the multiple comparisons being made.

### Relationship between smoking status and having food allergies

**Raw counts table**

| | Yes | No | NA |
|---|---|---|---|
| **Yes** | 263 | 2598 | 5 |
| **No** | 333 | 3013 | 6 |
| **NA** | 236 | 3645 | 438 |

**Proportion table (% within total)**

| | Yes | No | NA |
|---|---|---|---|
| **Yes** | 2.50 | 24.66 | 0.05 |
| **No** | 3.16 | 28.59 | 0.06 |
| **NA** | 2.24 | 34.59 | 4.16 |

Pearson's Chi-squared test
data: cont_table
X-squared = 659.81, df = 4, p-value < 2.2e-16
Based on the chi-square test results ($\chi^2 = 659.81$, df = 4, p < 2.2e-16), there is a statistically significant relationship between smoking status and food allergies in this population.

Looking at the completed data (excluding NA values):

1. Among smokers (Yes):
   - 263 reported food allergies
   - 2,598 reported no food allergies
   - Roughly 9.2% of smokers reported food allergies
2. Among non-smokers (No):
   - 333 reported food allergies
   - 3,013 reported no food allergies
   - Roughly 9.9% of non-smokers reported food allergies

### Summary

- While the chi-square test showed statistical significance, the actual clinical difference in food allergy rates between smokers and non-smokers is very small (about 0.7% difference)

- There's a substantial amount of missing data (NA values: 236 for allergies, 438 for smoking status), which should be considered when interpreting these results
- The high chi-square value (659.81) m likely driven by the large sample size rather than a meaningful clinical difference

More will be seen when accounting for potential confounders in regression

**Relationship between not affording balanced meals (food security) and food allergies**

Sometimes true and always true were re-classified as one - True

Contingency table

**Raw counts table**

| | Yes | No | NA |
|---|---|---|---|
| **True** | 152 | 1915 | 112 |
| **Never True** | 673 | 7233 | 334 |
| **NA** | 7 | 108 | 3 |

**Proportion table (% within total)**

| | Yes | No | NA |
|---|---|---|---|
| **True** | 1.44 | 18.17 | 1.06 |
| **Never True** | 6.39 | 68.64 | 3.17 |
| **NA** | 0.0 | 1.02 | 0.03 |

**Pearson's Chi-squared test**
**data: cont_table**
**X-squared = 9.4713, df = 4, p-value = 0.05034**

**Statistical Significance**

The Chi-square test ($\chi^2 = 9.47$, df = 4, p = 0.05034) suggests a marginally significant association between the variables.
The p-value (0.05034) is slightly above 0.05 threshold, indicating that the observed differences may be due to chance, though the result is borderline significant.

**Relationship between health insurance status (having health insurance) and food allergies**

Contingency table

Raw Table

| | Yes | No |
|---|---|---|
| Yes | 673 | 7405 |
| No | 156 | 1840 |

Prop Table

| | Yes | No |
|---|---|---|
| Yes | 8.331270 | 91.668730 |
| No | 7.815631 | 92.184369 |

Pearson's Chi-squared test with Yates' continuity correction
data: cont_table
X-squared = 0.49729, df = 1, p-value = 0.4807

The Chi-square test ($\chi^2 = 0.497$, df = 1, p = 0.4807) indicates no statistically significant association between the variables.

**Relationship between asthma-medical conditions and food allergies**

Contingency table

Raw Table Food allergy

| | Yes | No |
|---|---|---|
| Yes | 235 | 1214 |
| No | 596 | 8028 |

Prop Table Food allergy

| | Yes | No |
|---|---|---|
| Yes | 16.218081 | 83.781119 |
| No | 6.910946 | 93.089054 |

Pearson's Chi-squared test with Yates' continuity correction
data: cont_table
X-squared = 140.74, df = 1, p-value < 2.2e-16

The Chi-square test ($\chi^2 = 140.74$, df = 1, p < 2.2e-16) indicates a strong statistical association between the variables. From the graph and contingency table, having asthma diagnosis is strongly associated with having food allergy.

**Logistic Regression analysis of factors predicting presence or absence of food allergies**

**Variables:**

1. DBQ920 - Having food allergies - Yes or No - Dependent variable. Outcome is Yes – having food allergy
2. RIAGENDR - Gender - Male or Female
3. RIDAGEYR - Age in years
4. RIDRETH1 - Race/Ethnicity
5. INDFMPIR - Family income to poverty ratio, an SES index, continuous variable
6. DMDHHSIZ - Total number of people in the household, numerical
7. MCQ010 - Having an asthma diagnosis
8. HIQ011 - Covered by Health insurance, yes|No
9. FSD032C - Couldn't afford balanced meals, True|Never True (food security)
10. SMQ020 - Smoked at least 100 cigarettes in life
11. WHD020 - Current self-reported weight in pounds

## Results

**all:**

**glm (formula = DBQ920 ~ RIAGENDR + RIDAGEYR + RIDRETH1 + INDFMPIR + DMDHHSIZ + MCQ010 + HIQ011 + FSD032C + SMQ020 + WHD020, family = binomial (link = "logit"), data = complete_data)**

*The estimate represents the expected change in the dependent variable for a one-unit increase in the predictor (holding all other variables constant).*

**Log odds Coefficients.**

| Variable | Estimate | Std. Error | Z value | Pr(>\|z\|) | Significance |
|---|---|---|---|---|---|
| (Intercept) | 1.689e+00 | 2.996e-01 | 5.637 | 1.73e-08 | *** |
| RIAGENDRFemale | -4.019e-01 | 9.525e-02 | -4.220 | 2.45e-05 | *** |
| RIDAGEYR | 1.380e-03 | 2.897e-03 | 0.476 | 0.63374 | |
| RIDRETH1Other Hispanic | -5.672e-01 | 1.877e-01 | -3.022 | 0.00252 | ** |
| RIDRETH1Non-Hispanic White | -1.050e-01 | 1.545e-01 | -0.680 | 0.49659 | |
| RIDRETH1Non-Hispanic Black | -3.908e-01 | 1.675e-01 | -2.333 | 0.01964 | * |
| RIDRETH1Other Race Including Multiracial | -1.498e-01 | 2.406e-01 | -0.623 | 0.53349 | |
| INDFMPIR | -5.186e-02 | 3.209e-02 | -1.616 | 0.10611 | |
| DMDHHSIZ | 7.779e-02 | 3.205e-02 | 2.428 | 0.01520 | * |
| MCQ010No | 8.929e-01 | 1.096e-01 | 8.148 | 3.71e-16 | *** |
| HIQ011No | 1.520e-01 | 1.268e-01 | 1.198 | 0.23080 | |
| FSD032CNever True | 3.898e-02 | 1.279e-01 | 0.305 | 0.76057 | |
| SMQ020No | -4.509e-02 | 9.618e-02 | -0.469 | 0.63919 | |
| WHD020 | 4.054e-05 | 7.211e-05 | 0.562 | 0.57396 | |

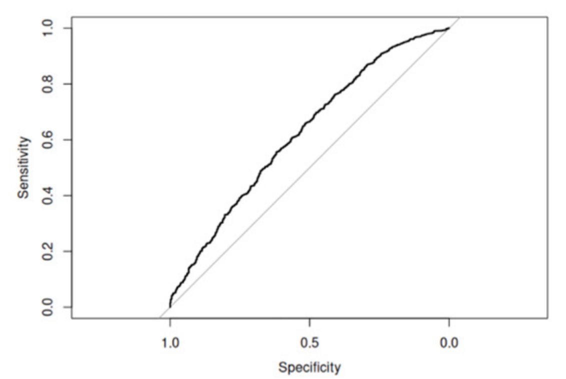
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
(Dispersion parameter for binomial family taken to be 1)
Null deviance: 3544.0 on 5537 degrees of freedom
Residual deviance: 3427.2 on 5524 degrees of freedom
Akaike Information Criterion(AIC): 3455.2
Number of Fisher Scoring iterations: 5

## Odds Ratio of variables with 95% Confidence Intervals

| Variable | Odds Ratio (OR) | 95% CI Lower | 95% CI Upper |
|---|---|---|---|
| (Intercept) | 5.4135*** | 3.0216 | 9.7832 |
| RIAGENDRFemale | 0.6690*** | 0.5545 | 0.8057 |
| RIDAGEYR | 1.0014 | 0.9957 | 1.0071 |
| RIDRETH1Other Hispanic | 0.5671** | 0.3923 | 0.8199 |
| RIDRETH1Non-Hispanic White | 0.9003 | 0.6608 | 1.2119 |
| RIDRETH1Non-Hispanic Black | 0.6765* | 0.4851 | 0.9364 |
| RIDRETH1Other Race Including Multiracial | 0.8609 | 0.5426 | 1.3979 |
| INDFMPIR | 0.9495 | 0.8916 | 1.0111 |
| DMDHHSIZ | 1.0809* | 1.0156 | 1.1515 |
| MCQ010No | 2.4423*** | 1.9657 | 3.0215 |
| HIQ011No | 1.1641 | 0.9105 | 1.4974 |
| FSD032CNever True | 1.0398 | 0.8064 | 1.3321 |
| SMQ020No | 0.9559 | 0.7913 | 1.1539 |
| WHD020 | 1.0000 | 0.9999 | 1.0002 |

Model: "glm, DBQ920 ~ RIAGENDR + RIDAGEYR + RIDRETH1 + INDFMPIR + DMDHHSIZ + MCQ010 + HIQ011 + FSD032C + SMQ020 + WHD020, binomial(link = \"logit\"), complete_data"
Null: "glm, DBQ920 ~ 1, binomial(link = \"logit\"), complete_data"
$Pseudo.R.squared.for.model.vs.null
Pseudo.R.squared
McFadden 0.0329690
Cox and Snell (ML) 0.0208775
Nagelkerke (Cragg and Uhler) 0.0441682
$Likelihood.ratio.test
Df.diff LogLik.diff Chisq p.value
-13 -58.422 116.84 8.45e-19
$Number.of.observations
Model: 5538
Null: 5538

**Area under curve**




Area under the curve: 0.6229
Statistically Significant Predictors
Sex (Female vs. Male): Women had lower odds of the outcome compared to men (OR = 0.67, 95% CI: 0.55–0.81, p < 0.001).

Race/Ethnicity:
Other Hispanic individuals had significantly lower odds compared to the reference group (OR = 0.57, 95% CI: 0.39–0.82, p = 0.002).
Non-Hispanic Black individuals also had lower odds (OR = 0.68, 95% CI: 0.49–0.94, p = 0.020).
Household Size: Larger household size was associated with increased odds of the outcome (OR = 1.08, 95% CI: 1.02–1.15, p = 0.015).
Asthma (MCQ010 - No): Individuals without asthma had significantly higher odds of the outcome (OR = 2.44, 95% CI: 1.97–3.02, p < 0.001).

Non-Significant Predictors
Age (RIDAGEYR): Not significantly associated with the outcome (OR = 1.00, p = 0.634).
Income-to-Poverty Ratio (INDFMPIR): Did not reach statistical significance (OR = 0.95, p = 0.106).

Health Insurance (HIQ011 - No): No significant association with the outcome (OR = 1.16, p = 0.231).
Smoking Status (SMQ020 - No): Not significantly associated with the outcome (OR = 0.96, p = 0.639).
Weight (WHD020): No significant effect observed (OR = 1.00004, p = 0.574).

### Model Performance and Effect Size Interpretation

### Model Fit & Predictive Power

McFadden's Pseudo $R^2 = 0.033$, indicating a modest model fit.
Nagelkerke's Pseudo $R^2 = 0.044$, suggesting limited explanatory power.
Likelihood Ratio Test: The model significantly improves over the null model ($\chi^2 = 116.84$, $p < 0.001$).
AUC (Area Under the Curve) = 0.6229, indicating poor to fair discrimination ability.

### Effect Size Interpretation

Odds Ratios (OR): An OR above 1 suggests increased odds of the outcome, while an OR below 1 suggests reduced odds. Gender and Race/Ethnicity showed the strongest effects, with females and certain racial groups having significantly reduced odds.

MCQ010 (Medical Condition (Asthma - No) had the largest positive effect (OR = 2.44), suggesting that those without asthma are more likely to have the outcome.

The change in effect of asthma may be explained by the following, asthma may be more common in groups that are less likely to report food allergies e.g. in people with lower SES with limited access to healthcare which may have affected the relationship. Thus, asthma association with a variable (age, ethnic group/race, SES) that reduces odds of reporting food allergies, adjusting for these factors in the logistic regression may have changed the direction of this association between asthma and food allergies. Individuals with asthma may be more likely to admit to food allergies explaining the significant raw association found with the Chi square test. Furthermore, the relationship between food allergies and asthma is established in children and the dataset doesnt include those below the age of 18.

This logistic regression analysis identified sex, race/ethnicity, household size, and medical condition status (asthma) as significant predictors of individuals having food allergy.

## Discussion

Irritable bowel syndrome (IBS), inflammatory bowel disease (IBD), gastroduodenal ulcers, and colorectal cancer (CRC) are common gastrointestinal diseases that greatly affect public health. Their incidence, severity, and mortality are significantly determined by socioeconomic status (SES), racial and ethnic differences, nutrition, lifestyle behaviors, psychological stress, and access to healthcare. The findings show severe system inequities in the burden, severity, and healthcare costs associated with GI diseases such that there is an urgent need for targeted interventions promoting equitable access to healthcare and managing diseases.

### Socioeconomic Status and GI Health

Socioeconomic disparities were arguably among the greatest and most powerful influences upon GI health in terms of both disease risk and health care outcomes. According to BRFSS data, demographic factors including age, sex, and socioeconomic level appear to have an impact on both IBS and IBD.

Analysis revealed SES as a significant determinant of dietary quality such that those in lower-income categories were significantly more likely to incur a low-quality diet ($p < 0.0001$). Poor nutrition makes IBD and IBS worse, and restricted access to fresh, nutrient-rich foods poses a huge barrier to the proper management of disease among low-income populations. Diets heavy in processed foods, refined sugars, and unhealthy fats constitute an increasing burden of GI disease [15-17], while fiber-rich and probiotic-enhanced diets are supportive of gut health [18,19].

In addition, SES affects accessibility and utilization of health services. Access to health care is restricted for lower-income households as they tend to delay or forgo seeking medical help due to the expensive care, leading them to be diagnosed at later stages and have poorer outcomes. The research by May et al. reflects these disparities, revealing the fact that children from lower SES backgrounds are very likely to undergo emergency GI procedures [20]. Likewise, Adams et al. argue that deprived children have 51% higher risks of GI infections than more advantaged peers as further evidence for early life interventions in nutrition, hygiene, and preventive care [21].

In conclusion, according to BRFSS, socioeconomic status matters; as those with lower incomes are more likely to suffer from IBS because of dietary issues, restricted access to treatment, and elevated stress levels. Greater socioeconomic position may be associated with a greater reported prevalence of IBD, maybe as a result of easier availability to diagnostic tools.

### Behavioral and Lifestyle Factors in GI Disease Risk

The risk and development of gastrointestinal disorders are significantly influenced by behavioral variables, which include physical activity, alcohol consumption, smoking, and food. High-fat and ultra-processed meals are known to trigger flare-ups of IBD, whereas diets heavy in processed foods and sweets have been associated with a worsening of IBS symptoms. Additionally, smoking increases the risk of developing Crohn's disease, although it appears to exert a protective effect against ulcerative colitis. Similarly, alcohol consumption consistently exacerbates symptoms in both IBS and IBD, highlighting the critical impact of lifestyle choices on gastrointestinal health.

Given these links, lifestyle modifications must be at the core of public health programs. Alcohol reduction campaigns, smoking cessation programs, and community-based food education initiatives may be very beneficial to at-risk groups. Furthermore, increased physical activity may be a helpful preventative measure for both IBD and IBS since it has been linked to reduced inflammation and enhanced gastrointestinal motility.

Recent evidence further expands our understanding of lifestyle impacts on GI health. A Mendelian randomization analysis by Chen et al. provided novel insights into the causal role of sedentary behavior and physical activity in GI diseases. The study demonstrated that genetically predicted longer leisure screen time (LST)—a proxy for sedentary behavior—was associated with an increased risk of 16 GI diseases, including gastrointestinal reflux, gastric and duodenal ulcers, chronic gastritis, IBS, diverticular disease, Crohn's disease, ulcerative colitis, non-alcoholic and alcoholic liver diseases, cholangitis, cholecystitis, cholelithiasis, pancreatitis, and acute appendicitis. On the other hand, genetic predisposition towards moderate-to-vigorous physical activity related to lessened risk for at least 8 GI diseases, such as gastroesophageal reflux, gastric ulcer, yearly gastritis, IBS, cholecystitis, cholelithiasis, and pancreatitis. The study also exhibits that metabolic factors such as BMI, type 2 diabetes, and fasting insulin mediate these associations indicating that some benefits from increased physical activity and decreased sedentary behavior may come via metabolic health improvements. These findings advocate for integrated lifestyle interventions that not only promote regular physical activity but also emphasize reducing sedentary time as a strategy for GI disease prevention [23].

### Psychological Stress and the Gut-Brain Axis

Psychological stress is important in gastrointestinal health, especially in IBS. The gut-brain axis is extremely susceptible to stress, worry, and depression, which can worsen IBS symptoms by increasing gut motility and sensitivity. The BRFSS findings demonstrate a robust link between mental health and IBS, highlighting the need for integrated psychological treatment in GI illness management. Because of variations in gut-brain connections and hormonal factors, IBS is more common in women. Although illness may greatly impact both sexes, IBD, which includes Crohn's disease and ulcerative colitis, also has a modest female preponderance in some communities (BRFSS data).

Even though IBD is primarily an autoimmune condition, flare-ups and worsening disease outcomes have been associated with stress. The importance of integrating mental health into GI treatment is highlighted by the possibility that patients with high-stress lifestyles or comorbid mental health disorders may have an increased incidence of both conditions. As supplemental therapies, stress management techniques including gut-directed hypnotherapy, mindfulness-based stress reduction, and cognitive-behavioral therapy (CBT) should be taken into consideration.

### Healthcare Access and Regional Disparities

Access to healthcare continues to have a substantial impact on GI illness outcomes. May et al. identify gaps in routine care and early intervention by demonstrating that Medicaid patients, non-English speakers, and ethnic minorities are disproportionately more likely to require urgent GI surgeries [20]. Similarly, Adams et al. showed that barriers to healthcare access increased GI ailments among lower SES groups, particularly children [21].

Geographic variables influence disease burdens. According to Aldhaleei et al., West Virginia has the greatest rate of digestive disease mortality, although South Dakota, Kentucky, and New Mexico have all seen considerable rises [22]. Expanding access to primary care, preventative screenings, and specialized GI care in underserved regions might assist in closing these disparities.

### Racial and ethnic disparities in GI health

Data analysis on NHANES data revealed significant associations between ethnicity and morbidity. SES varied significantly among ethnic groups, as evidenced by the Kruskal Wallis rank sum test showing **$\chi^2 = 207.89$, $p < 0.0001$.** Further testing revealed that non-Hispanic Whites and Asian population had higher SES statuses and better quality diets as compared to Blacks and Hispanic populations, who reported more food insecurity.

There were also significant disparities among the FISI scores (**$\chi^2 = 9.78$, $p = 0.044$**) with Mexican Americans scoring higher than their Black counterparts ($p = 0.0127$).

Surprisingly, race and ethnicity had a highly significant association with food allergies with Mexican Americans having a significant disparity vis a vis other Hispanics (**$p < 0.0001$),** and Non- Hispanic Blacks ($p=0.00019$). Compared to non-Hispanic whites, Blacks had lower odds of food allergies ($p= 0.0196$, OR=0.6765), as did Other Hispanics ($p=0.00025$, OR=0.5671).

## Conclusion

This study investigated the associations between race, ethnicity, and socioeconomic status and gastrointestinal (GI) health outcomes, utilizing nationally representative data from the National Health and Nutrition Examination Survey (NHANES). The results demonstrated substantial disparities in dietary quality and the prevalence of food allergies across different socioeconomic strata, with low-income and minority populations disproportionately affected. Sex, race, and household size emerged as significant predictors of food allergy presence, whereas age, weight, income-to-poverty ratio, smoking status, and insurance coverage did not demonstrate statistical significance.

After adjusting for sociodemographic factors, the initially observed positive association between asthma and food allergies reversed, suggesting that both underreporting due to limited healthcare access and potential immune adaptation from chronic environmental exposures in disadvantaged populations may obscure true prevalence patterns.

Contingency tables were used to compare food allergy prevalence among individuals with and without health insurance. An analysis was conducted to examine the relationship between asthma diagnosis and food allergies, showing a strong association between individuals with asthma being significantly more likely to report food allergies per the chi square test with yates correction. However, after accounting for covariates through a multivariable logistic regression model used to identify predictors of food allergy status including SES, asthma diagnosis, food security status, health insurance status, asthma diagnosis, race, age, weight and gender, it was found that the association reversed from the bivariate analysis: Mcfadden's, Nagelkerke and Likelihood ratio testing were performed for the adjusted model showing fair discrimination ability and that there may be confounding effects of SES and lower healthcare access in populations that may be less likely to report food allergies. A limitation of this is that only adults 18 and up are included in the NHANES data.

Chi-square analyses revealed significant associations between food allergies and factors such as gender, race/ethnicity, household size, and asthma diagnosis. Logistic regression further identified female gender, Hispanic and Non-Hispanic Black ethnicity, larger household size, and asthma diagnosis as significant predictors of food allergy presence: Specifically females were less likely to report food allergies compared to males.

In regards to asthma, those without asthma showed higher odds of food allergies in the adjusted multivariate model: Interestingly, while the unadjusted analyses demonstrated a positive association between asthma and self-reported food allergy, this relationship attenuated and even reversed direction after adjusting for sociodemographic variables. Beyond disparities in access to healthcare and diagnostic labeling, biologically driven differences in immune system development may also explain the lower prevalence of self-reported food allergy and asthma among socioeconomically disadvantaged children. Chronic early-life exposure to diverse environmental antigens—such as microbial byproducts, pollutants, and allergens—may shape immune tolerance pathways, including reduced mast cell hyperreactivity and modulation of IgE-mediated responses. Emerging research also suggests that gut microbiota diversity, often influenced by diet, hygiene, and environmental conditions, plays a critical role in regulating immune homeostasis and preventing allergic sensitization. While underdiagnosis and limited access to healthcare partly explain lower reported asthma and allergy rates in lower-income adults, biology may also play a role. Chronic exposure to pollutants, microbes, and allergens in disadvantaged environments could blunt immune overreactions over time. Instead of triggering hypersensitivity, repeated exposures may recalibrate immune thresholds—dampening mast cell activation or Th2 dominance. In contrast, cleaner environments in higher-income areas may promote immune systems that overreact to otherwise harmless stimuli. Furthermore, the reversal of the association of asthma and food allergy from the bivariate to the multivariate analysis suggests that the initial association may have been confounded by differences in socioeconomic status, race/ethnicity, and household characteristics. Individuals with asthma may be more concentrated in lower-income or underserved populations, where access to allergy testing and healthcare resources is limited. As a result, food allergies may be underreported or underdiagnosed in these groups, leading to an apparent reduction in the observed association once these social determinants are accounted for. This highlights the importance of considering structural disparities in health reporting and diagnosis when interpreting epidemiological associations. So what appears as a paradoxical protective effect of low SES may reflect both underreporting and long-term immune adaptation to a harsher environment.

These findings underscore the critical need for public health interventions aimed at enhancing dietary quality and healthcare access among socially and economically disadvantaged groups. Addressing structural inequities through patient education, equitable care delivery, and policies promoting food security, nutritional adequacy, and comprehensive healthcare access is essential. Additionally, incorporating mental health support including stress management and lifestyle interventions may contribute to improved clinical outcomes. Future research should broaden its scope to examine trends and determinants of GI health across diverse populations, including pediatric cohorts and underrepresented racial and ethnic groups. Investigations should also consider cultural dietary patterns, real-world implementation of nutritional policies, and the effectiveness of targeted interventions. Advancing equity in healthcare delivery and research will be pivotal in improving GI health outcomes across all segments of the population.

In this NHANES analysis, we found that ethnicity modifies the association between food allergy and asthma. The relationship between food allergy and asthma was strongest among Non-Hispanic Black participants. Within each ethnic stratum, adjusting for socioeconomic factors such as income and education attenuated the observed associations. This indicates confounding by socioeconomic status causing a higher risk attribution than would otherwise be seen. The relationship between food allergy and asthma in the U.S. population involves effect modification by ethnicity and confounding by socioeconomic status.

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