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Impact of Regional Food Insecurity and Social Vulnerability on Inpatient IBD Severity in the State of Texas

Abstract

Inflammatory Bowel Disease (IBD) is an autoimmune disorder involving chronic inflammation of the gastrointestinal tract. While research has linked ultra-processed food consumption to its pathophysiology, the role of food access on the severity of IBD remains understudied. This cross-sectional study of Texas inpatient hospitalization data evaluated how county-level food access and social vulnerabilities affect IBD severity. Records of 2,000 adults hospitalized for IBD in 2016 and 2018 were merged with county-level data from the Feeding America and CDC Social Vulnerability Index datasets. An ordinal logistic regression model assessed predictors of clinical severity using All-Patient Refined Diagnosis-Related Groups scores. The county-level food insecurity rate was a significant predictor of higher clinical severity (OR = 1.034, p = 0.042). Conversely, individuals with low income who do not qualify for SNAP or other federal nutrition programs exhibited lower odds of severe illness (OR = 0.883, p < 0.001). Advanced age was also a strong predictor, while neither sex nor composite SVI markers reached statistical significance. Overall, these findings identify regional food insecurity as a social determinant of health strongly associated with increased clinical severity of IBD, demonstrating that food access affects clinical outcomes at admission.

Keywords: Medicine; Inflammatory Bowel Disease; Social Determinants of Health; Food Insecurity;

1. Introduction

Inflammatory Bowel Disease (IBD) encompasses Crohn's Disease and Ulcerative Colitis, two chronic, immune-mediated conditions characterized by relapsing inflammation of the gastrointestinal tract (Fakhoury et al., 2014; Reddavide et al., 2018). Since 2015, IBD prevalence in the United States has been increasing by 1.72%. With 0.7% of Americans having IBD, total healthcare costs in 2025 were estimated to be around $25,243,078,919 (Coward et al., 2015). While the exact etiology of IBD remains unknown, it is widely accepted to involve immunological, environmental, physiological, and psychosocial factors, which trigger existing genetic predispositions and cause alterations in the gut microbiome (Figure 1).

The exposome, the total lifetime burden of environmental exposures, may affect IBD symptoms in those with genetic predisposition to IBD (Coward et al., 2015). At the cellular level, these external factors trigger abnormal immune responses in the gastrointestinal tract and cause the host-microbiome symbiosis to enter a state of chronic dysbiosis (Figure 1). Ultimately this interaction creates a pro-inflammatory GI environment. Of these triggers, diet is a major environmental factor that may influence the onset and prognosis of IBD. High consumption of ultra-processed foods (UPFs) is positively associated with an increased risk of IBD across multiple categories (Abegunde et al., 2016). The gut microbiome is particularly sensitive to the chronic nutritional deficiencies and erratic dietary patterns that affect individuals with food insecurity and high consumption of UPFs. Repeated exposure to these stressors perpetuates the state of dysbiosis already characteristic of IBD pathophysiology (Nguyen et al., 2020). The barrier of the mucosal lining in the gastrointestinal tract becomes impaired due to nutritional inadequacy and increases intestinal permeability to pathogens and thus amplifying the immunological response that causes chronic inflammation in IBD patients (Nguyen & Bollegala, 2014).

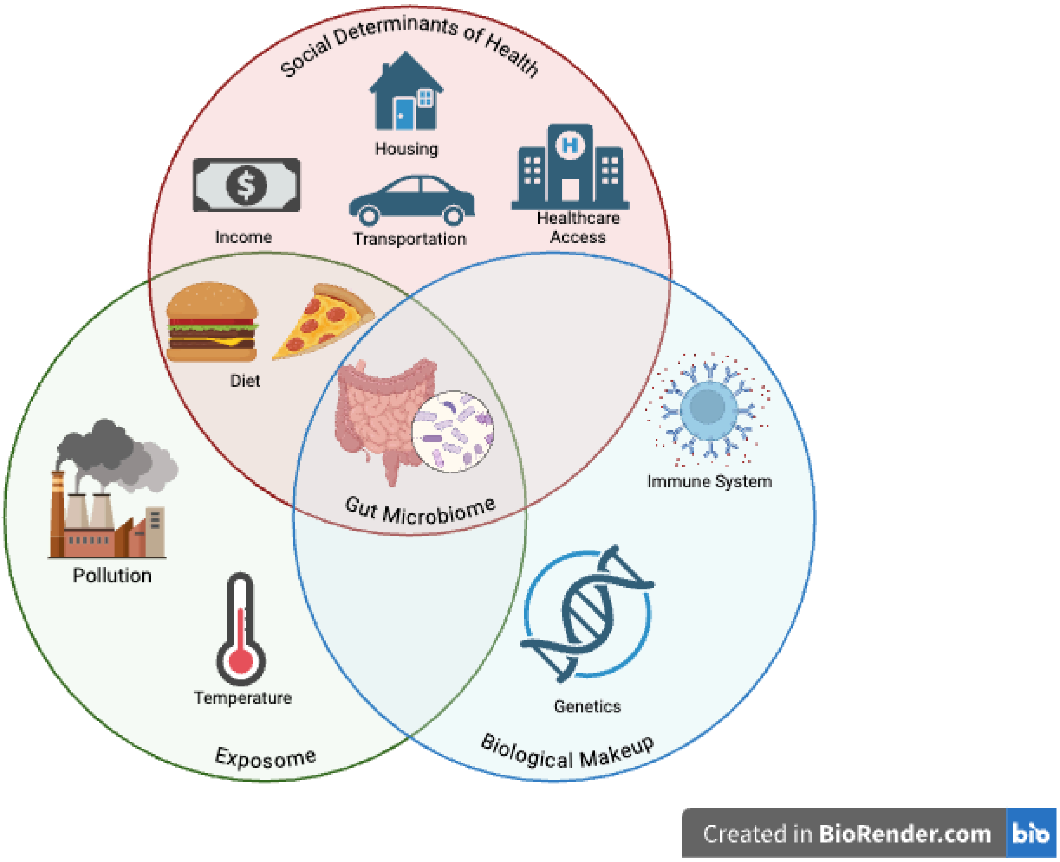


Figure 1: Contributing factors to IBD pathophysiology; created with BioRender.com; the various contributing factors to IBD pathophysiology are illustrated above. The exposome measures all environmental exposures an individual has experienced throughout their lifetime. Diet is a component of the external exposome that influences the internal exposome, namely the gut microbiome and the immune system. Genetic predisposition makes individuals more prone to developing IBD. The social determinants of health, such as housing, income level, access to transportation, and proximity to the hospital, all influence disease severity and patient outcomes.

This is particularly a problem given the prevalence of UPF and food insecurity (FI). Data from the CDC's 2023 National Health and Nutrition Examination Survey (NHANES) indicated that UPFs accounted for roughly 55.0% of the average American's total caloric intake (Narula et al., 2021). While food insecurity, defined as inconsistent and unreliable access to food necessary for an active, healthy life, affects 14% of the current population in the United States. In an analysis of the National Health Interview Survey carried out by the CDC, it was found that individuals with IBD face a higher risk of experiencing FI than the average US adult, with 14% of individuals with IBD in the US eligible for classification as food insecure (Gold et al., 2024; Baniqued et al., 2025).

Yet, FI is just one component of the Social Determinants of Health (SDoH) that influence IBD quality of care and health outcomes. SDoH, defined as the conditions in which people grow, live, learn, and work, are grouped into five categories: financial stability, access to quality education, quality healthcare, neighborhood environment, and community support (Chirayath et al., 2025; Figure 1). Of these factors, neighborhood socioeconomic disadvantage has been independently associated with 30-day mortality for patients with common gastrointestinal diseases, and lower socioeconomic status has also been linked to increased rates of outpatient visits in persons with IBD (Vrtikapa et al., 2025; Clark et al., 2025). Given the documented impacts of these structural inequalities on the health outcomes of IBD patients, recent research has focused on identifying their compounding effects alongside patient demographics and physiological symptoms to better track disease progression and healthcare utilization of IBD patients.

A study by Shah et al. (2022) used clinical charts and self-reported surveys from a major Texas hospital system to evaluate the effectiveness of incorporating SDoH, alongside disease extent and behavior, in IBD patients for predicting whether patients would need hospitalization or surgery (Shah et al., 2022). Although the model demonstrated that incorporating the SDoH improves the performance of predictive models, the fact that the majority of patients were insured and reported no financial, food security, or transportation concerns led to the conclusion that these factors have limited impact on the likelihood of adverse health outcomes.

While existing research demonstrates the effect of self-reported social barriers on predicting the need for inpatient care, there is a significant gap in the literature regarding the impact of structural disparities among different age and sex groups on IBD clinical severity. Accordingly, this study examines how county-level food-access disparities and local socioeconomic vulnerabilities affect the severity of inflammatory bowel disease across demographic groups in Texas.

2. Methods

The Texas Health Care Information Collection (THCIC) program was used to collect inpatient hospitalization records for the years 2016 and 2018. Patients were filtered based on the Major Diagnostic Category (MDC) and refined to include only Inflammatory Bowel Disease based on All-Patient Refined Diagnosis-Related Groups (APR-DRG). Each patient's age, race/ethnicity, and illness severity were compiled. The APR-DRG severity scale was used to quantify the patient's severity of illness, with 1 indicating Mild, 2 Moderate, 3 Major, and 4 Extreme.

Food insecurity data were obtained from the Feeding America dataset. County-level food insecurity rates and average meal costs were compiled for each calendar year. The percentage of food-insecure individuals with incomes below the federal or state eligibility limit for nutrition programs (typically 130% of the Federal Poverty Line) was also collected. Additionally, the percentage of food-insecure individuals with incomes above SNAP eligibility but within the range for other federal nutrition programs (typically 130-185% of the Federal Poverty Line) was included.

The analysis focused on the 2016 and 2018 retrospective cohorts to correspond to the CDC's Social Vulnerability Index (SVI) dataset, which is released biennially. The composite social vulnerability score and its four principal theme scores (Socioeconomic Status, Household Characteristics, Racial and Ethnic Minority Status, and Housing Type and Transportation) were compiled for all 254 counties in Texas. Socioeconomic Status (Theme 1) measures individuals in a county who are below the poverty level, unemployed, classified as low income, or without a high school diploma. Household Composition and Disability (Theme 2) captured household composition by accounting for residents aged 65 or older, those aged 17 or younger, civilians living with a disability, and single-parent households. Minority Status and

Language (Theme 3) evaluated the proportion of the population identifying as a minority, as well as the proportion of individuals who speak English "less than well." Finally, Housing Type and Transportation (Theme 4) assessed infrastructural vulnerabilities, including residents living in multi-unit structures, mobile homes, crowded housing, group quarters, or households without access to a vehicle.

Restricting the study period to 2016 and 2018 also excluded the 2020 dataset to avoid the potential clinical and healthcare utilization confounders introduced by the COVID-19 pandemic.

For each record acquired from the THCIC dataset, the patient's county of residence and data year were used to assign their county-level food insecurity and SDoH metrics. This data was used to run an ordinal logistic regression model in R to evaluate the effects of these multi-level demographic and socioeconomic factors on IBD disease severity.

3. Results

A total of 2,000 individuals who were hospitalized for IBD in the state of Texas in 2016 and 2018 were identified. Within this cohort, females represented 49.95% of the sample (n = 999), males represented 41.40% (n = 828), and 8.65% (n = 173) had an unidentified or unknown sex (Table 1a). Pediatric patients (ages 0-17) comprised 11.05% (n = 221) of the cohort. The primary age demographic of the sample was 18-44 years, at 34.45% (n = 689), while the middle-aged 45-64 years age group represented 27.50% of the sample (n = 550). Older demographics comprised 292 individuals aged 65 to 74 and 248 aged 75 and older, representing 14.60% and 12.40% of the population, respectively (Table 1a).

When evaluating baseline clinical severity, the majority of hospitalized individuals had moderate illness severity, accounting for 39.75% (n = 795). Extreme severity of illness was the least prevalent manifestation, accounting for 7.65% of the total cohort (n = 153). Additionally, 501 individuals (25.05%) presented with minor severity of illness, and 551 individuals (27.55%) with major severity of illness.

At the county level, the median percentage of food-insecure individuals with household incomes at or below their state's Supplemental Nutrition Assistance Program (SNAP) gross income limit was 35.40% (Table 1b). The median percentage of food-insecure individuals with household incomes above the SNAP gross income limit but within the federal gross income limit for other federal nutrition programs, such as WIC, was 2.93%. Across all 254 counties over two years, the median cost per meal was $2.87.

For overall county-level social vulnerability metrics, the overall median social vulnerability score across all categories was 0.5178 (Table 1b). When examining the stratified subgroups, the median score was 0.4308 for socioeconomic status (Theme 1), 0.3439 for household characteristics (Theme 2), 0.5534 for Racial and Ethnic Minority Status (Theme 3), and 0.5810 for Housing Type and Transportation (Theme 4). Patient demographics and county-level socioeconomic summary statistics are shown in Table 1a and Table 1b.

Table 1a. Patient demographics and severity of illness (n = 2000)

Demographic category	Patient count (n)	Percentage (%)
Sex		

Female	999	49.95%
Male	828	41.40%
Unknown	173	8.65%
Age		
0-17	221	11.05%
18-44	689	34.45%
45-64	550	27.50%
65-74	292	14.60%
75+	248	12.40%
APR-DRG illness severity		
Minor	501	25.05%
Moderate	795	39.75%
Major	551	27.55%
Extreme	153	7.65%

Table 1b. County-level environmental and socioeconomic medians

Metric	**Value**
% FI ≤ low threshold	Median: 35.40%
% FI between thresholds	Median: 2.93%
Cost per meal ($)	Median: $2.87
RPL Theme 1 (socioeconomic status)	Median: 0.4308
RPL Theme 2 (household characteristics)	Median: 0.3439
RPL Theme 3 (racial & ethnic minority status)	Median: 0.5534
RPL Theme 4 (housing type & transportation)	Median: 0.5810
RPL themes overall	Median: 0.5178

Note: Ranked Percentile (RPL) values range from 0 to 1, with higher values signifying greater vulnerability. % FI ≤ Low Threshold: percentage of food insecure individuals at or below SNAP income level. % FI Between Thresholds: percentage of food insecure individuals with incomes above SNAP eligibility but below WIC/other program levels.

Analysis of IBD severity (2016 and 2018)

The associations between county-level food insecurity, demographic factors, and IBD severity are summarized in Table 2.

Table 2. Odds ratios for predictors of increased IBD severity (2016 and 2018)

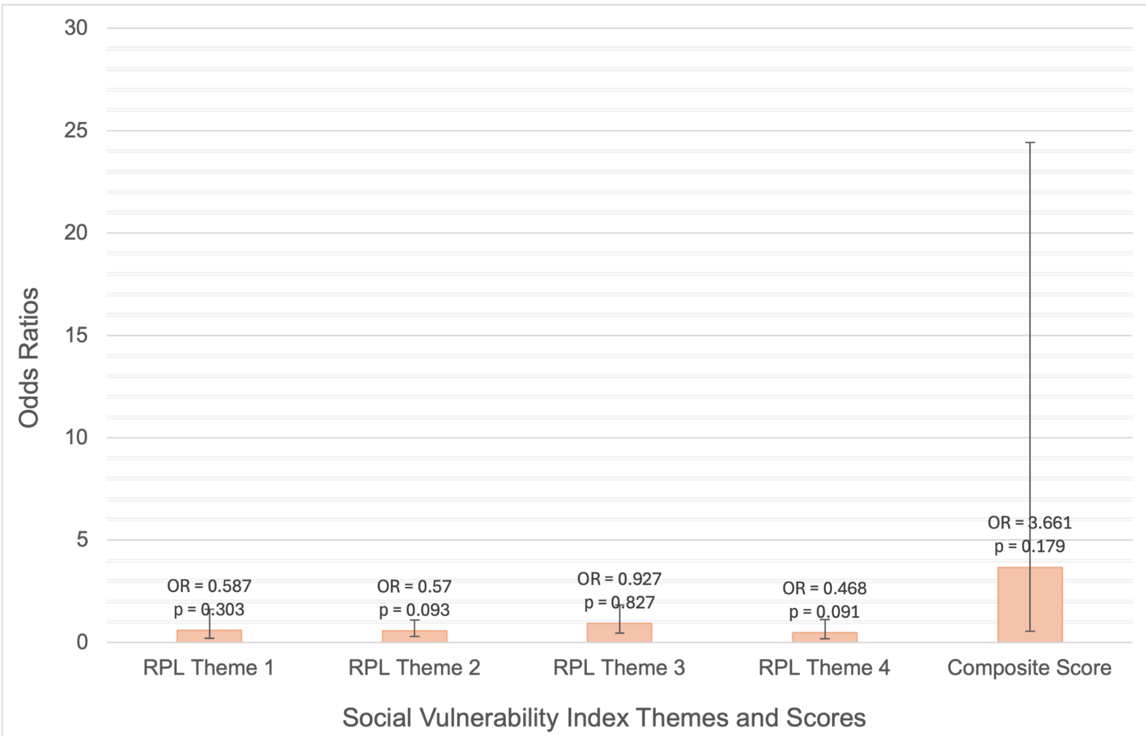
Predictor	Odds ratios (95% CI)	p-value
Food insecurity rate	1.034 (1.001, 1.067)	0.042*
% FI between thresholds	0.883 (0.824, 0.947)	<0.001*
% FI low threshold	1.001 (0.998, 1.004)	0.432
Cost per meal	1.16 (0.661, 2.033)	0.606
Age 18-44	0.842 (0.63, 1.125)	0.243
Age 45-64	1.066 (0.794, 1.433)	0.671
Age 65-74	1.461 (1.056, 2.021)	0.022*
Age 75+	2.087 (1.494, 2.919)	<0.001*
Sex M	1.002 (0.846, 1.188)	0.980
Sex F	0.998 (0.842, 1.182)	0.980
Sex unknown	1.184 (0.873, 1.605)	0.278

Note: **Statistically significant value with the p-value* < 0.05.

For 2016 and 2018, county-level food insecurity emerged as a statistically significant predictor of more severe manifestations of IBD, with a 3.4% increase in odds per 1% increase in food insecurity (OR = 1.034, $p = 0.042$) (Table 2). The percentage of food-insecure individuals at or below the state's SNAP gross income limit (165% of the Federal Poverty Level) was associated with slightly higher odds of greater IBD severity; the relationship was not significant (OR = 1.001, $p = 0.432$). In contrast, the percentage of food-insecure individuals with household incomes above the SNAP gross income limit but below the upper gross income threshold for alternative federal nutrition programs was significantly associated with lower odds of IBD severity (OR = 0.883, $p < 0.001$). Despite the slight increase in odds of greater illness severity, the average cost per meal demonstrated no significant impact (OR = 1.160, $p = 0.606$).

Beyond food insecurity metrics, age also appeared as a statistically significant predictor of patient severity of illness, with older age groups having a strong positive association with increased IBD severity compared to younger patients (Table 2). The geriatric cohort aged 75 years and above exhibited more than double the odds of experiencing increased IBD severity (OR = 2.087, $p < 0.001$). The 65-74-year age group exhibited a similarly significant positive association, although to a lesser extent, with an estimated 46% increase in the odds of heightened clinical severity (OR = 1.461, p = 0.022). Despite the weak correlation, the 45-64-year age group showed slightly higher odds of IBD severity (OR = 1.066, p = 0.671), while the 18-44-year age group showed lower odds of IBD severity (OR = 0.842, p = 0.243).

Graph 1. Association of SVI RPL Themes and the SVI Composite Score of a County with IBD Severity



Neither the composite social vulnerability score nor the four social vulnerability themes were statistically significant predictors of increased IBD severity (Graph 1). Measures of economic hardship and financial resilience, as represented by Theme 1 (Socioeconomic Status), were inversely associated with the severity of IBD (OR = 0.587, p = 0.303). Similarly, Theme 2, involving care dependency and household income sources, showed lower odds of severity, though not statistically significant (OR = 0.570, p = 0.093). The association between severity of illness and county-level racial and ethnic minority distributions (Theme 3) was close to an OR of 1 (p = 0.827). Neighborhood structural dynamics, such as housing density and transportation infrastructure (Theme 4), were associated with lower odds of extreme IBD presentation but were not statistically significant (OR = 0.468, p = 0.091). The aggregation of these themes yielded a county's composite SVI score, which was associated with three times higher odds of experiencing a more severe manifestation of disease. However, this was not statistically significant (OR = 3.661, p = 0.179) (Graph 1).

Finally, the association between clinical disease severity and patients' recorded sex was evaluated. Male patients had greater odds (OR = 1.002) of experiencing more severe IBD symptoms compared to female patients (OR = 0.998); however, neither finding was statistically significant. Interestingly, individuals whose sex was classified as "unknown" experienced greater odds of experiencing more severe IBD as well (OR = 1.184), though this finding was not statistically significant either (Table 2).

4. Discussion

In this cross-sectional study of adults hospitalized for IBD in Texas in 2016 and 2018, the correlation between food insecurity, income level, social vulnerability, and disease severity was analyzed. Individuals faced 3.4% higher odds of experiencing more severe manifestations of IBD for each percentage point increase in county-level food insecurity rates. A potential explanation is that food-insecure IBD patients are 27% more likely to consume ultra-processed foods and 29% less likely to consume unprocessed foods compared to those who are food-secure (Nguyen et al., 2020). Furthermore, cross-sectional analyses of the NHANES show that food insecurity is associated with 21% higher odds of elevated C-reactive protein (an inflammatory marker) and 36% higher odds of high white blood cell counts, demonstrating that the dietary patterns of food-insecure patients cause inflammation and immune overactivation (Gowda et al., 2012). An additional explanation includes that UPFs are also nutritionally deficient and may delay healing (Lobionda et al., 2019; Scaldaferri et al., 2017). The mucosal lining of the gastrointestinal tract becomes impaired due to nutritional inadequacy, increasing intestinal permeability and the immune response that causes IBD flares. Further consequences include prolonged hospitalization, infection, venous thromboembolism, and increased postoperative mortality (Kane et al., 2014; Michielan & D'Incà, 2015; Men et al., 2019). Malnutrition affects 65-75% of patients with Crohn's disease and 18-62% of patients with ulcerative colitis and thus this is a major concern for this population (Scaldaferri et al., 2017). Establishing this link, the study demonstrates that food access metrics can indicate geographic regions where hospitalized IBD patients are at increased risk of severe illness.

Another finding of this paper was the significant correlation between individuals qualifying for federal nutrition programs and IBD severity. The percentage of food-insecure individuals whose incomes fell above the SNAP gross income limit but within the upper threshold for alternate federal nutrition programs was significantly associated with lower odds of IBD severity (OR = 0.883, $p < .001$). These individuals are within the "SNAP gap," where household income exceeds the SNAP eligibility threshold yet food insecurity rates remain elevated at approximately 25% (Wentworth et al., 2018). Despite being food insecure, these households have somewhat greater financial resources than those at or below the SNAP threshold, which may buffer the most severe forms of nutritional deprivation. By contrast, the percentage of food-insecure individuals at or below the SNAP income threshold did not reach statistical significance (OR = 1.001, $p = 0.432$). This finding suggests an unprotective effect of SNAP participation, which is contrary to current disseminated information, as the program has been shown to reduce the likelihood of food insecurity by approximately 30% among enrolled households (Geanacopoulos et al., 2025).

Beyond food access, age emerged as one of the most significant predictors of IBD severity in the cohort. Patients aged 75 years and older had more than double the odds of experiencing more severe manifestations of IBD compared to the pediatric age group (OR = 2.087, $p < .001$). At the same time, the 65-74-year cohort exhibited a similarly significant positive association (OR = 1.461, $p = 0.022$). The results are consistent with the recorded growing global burden of IBD in older adults. The absolute number of elderly IBD cases more than doubled globally between 1990 and 2021, increasing from

573,500 to 1,278,190, and projections indicate that elderly IBD prevalence may reach 2,316,000 by 2051, with deaths and disability-adjusted life years projected to increase to 75,000 and 1,401,000, respectively (Liu et al., 2024). This pattern could be explained by elderly patients' immunosenescence, the gradual decline of the immune system that occurs with age, which results in the impaired function of dendritic cells, phagocytes, and natural killer cells (Berrut and Decker, 2015). Dysfunction of these innate immune cells results in the gut microbiome secreting pro-inflammatory cytokines and mediators, which destroy tissue and create excessive fibrosis in the GI tract (Saez et al., 2023; Steinbach & Plevy, 2014). Ultimately, these age-related immune changes directly drive the heightened disease severity observed in older patients, as this study found.

In contrast to age and food insecurity, neither sex nor county-level social vulnerability achieved statistical significance as a predictor of IBD severity. This study found that males experience worse severity of illness compared to females, supporting prior findings that male patients are 42% more likely to require surgery than female patients (Rasmussen et al., 2024). Despite high odds ratios, the lack of statistical significance across nearly all social vulnerability scores is likely caused by healthcare utilization patterns. Because publicly insured patients have 2.82 times higher odds of high inpatient costs and 2.50 times higher odds of high emergency spending, while low-income IBD patients are 62% less likely to utilize outpatient services, the severity scores in administrative datasets become inflated (Park et al., 2014).

Limitations

The paper assumes that individuals included in the THCIC dataset are consistent across all datasets used in the study. The use of county-level data to represent individual patient experiences introduces potential for error, since aggregate measures may not accurately represent specific patients within those counties. Restricting the study period to 2016 and 2018 to exclude COVID-19-related healthcare disruptions limits the generalizability of these conclusions. The significant proportion of patients with unidentified or unknown sex also makes it difficult to assess the impact of sex on disease outcomes.

5. Conclusion

This study contributes a novel population-level perspective on the determinants of IBD severity in Texas, a state defined by geographic and demographic heterogeneity in food access and socioeconomic vulnerability. The study revealed that county-level food insecurity and advanced age significantly increase the odds of severe IBD presentation. Conversely, neither sex nor county-level social vulnerability measures could predict clinical severity. This emphasizes the need for IBD management to incorporate food-access screening into patient care. The incorporation of targeted nutritional interventions and assistance with navigating federal food assistance programs into IBD care pathways may represent a meaningful, actionable strategy for lessening the disparate burden of this severe chronic disease among vulnerable patient populations. Incorporating food access screenings into IBD treatments has the potential to reduce severe, resource-intensive hospitalizations among vulnerable patient populations.

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Impact of Regional Food Insecurity and Social Vulnerability on Inpatient IBD Severity in the State of Texas

Abstract

Inflammatory Bowel Disease (IBD) is an autoimmune disorder involving chronic inflammation of the gastrointestinal tract. While research has linked ultra-processed food consumption to its pathophysiology, the role of food access on the severity of IBD remains understudied. This cross-sectional study of Texas inpatient hospitalization data evaluated how county-level food access and social vulnerabilities affect IBD severity. Records of 2,000 adults hospitalized for IBD in 2016 and 2018 were merged with county-level data from the Feeding America and CDC Social Vulnerability Index datasets. An ordinal logistic regression model assessed predictors of clinical severity using All-Patient Refined Diagnosis-Related Groups scores. The county-level food insecurity rate was a significant predictor of higher clinical severity (OR = 1.034, $p = 0.042$). Conversely, individuals with low income who do not qualify for SNAP or other federal nutrition programs exhibited lower odds of severe illness (OR = 0.883, $p < 0.001$). Advanced age was also a strong predictor, while neither sex nor composite SVI markers reached statistical significance. Overall, these findings identify regional food insecurity as a social determinant of health strongly associated with increased clinical severity of IBD, demonstrating that food access affects clinical outcomes at admission.

Keywords:
Medicine;Inflammatory Bowel Disease; Social Determinants of Health; Food Insecurity;

1. Introduction

Inflammatory Bowel Disease (IBD) encompasses Crohn's Disease and Ulcerative Colitis, two chronic, immune-mediated conditions characterized by relapsing inflammation of the gastrointestinal tract (Fakhoury et al., 2014; Reddavide et al., 2018). Since 2015, IBD prevalence in the United States has been increasing by 1.72%. With 0.7% of Americans having IBD, total healthcare costs in 2025 were estimated to be around $25,243,078,919 (Coward et al., 2015). While the exact etiology of IBD remains unknown, it is widely accepted to involve immunological, environmental, physiological, and psychosocial factors, which trigger existing genetic predispositions and cause alterations in the gut microbiome (Figure 1).

The exposome, the total lifetime burden of environmental exposures, may affect IBD symptoms in those with genetic predisposition to IBD (Coward et al., 2015). At the cellular level, these external factors trigger abnormal immune responses in the gastrointestinal tract and cause the host-microbiome symbiosis to enter a state of chronic dysbiosis (Figure 1). Ultimately this interaction creates a pro-inflammatory GI environment. Of these triggers, diet is a major environmental factor that may influence the onset and prognosis of IBD. High consumption of ultra-processed foods (UPFs) is positively associated with an increased risk of IBD across multiple categories (Abegunde et al., 2016). The gut microbiome is particularly sensitive to the chronic nutritional deficiencies and erratic dietary patterns that affect individuals with food insecurity and high consumption of UPFs. Repeated exposure to these stressors perpetuates the state of dysbiosis already characteristic of IBD pathophysiology (Nguyen et al., 2020). The barrier of the mucosal lining in the gastrointestinal tract becomes impaired due to nutritional inadequacy and increases intestinal permeability to pathogens and thus amplifying the immunological response that causes chronic inflammation in IBD patients (Nguyen & Bollegala, 2014).

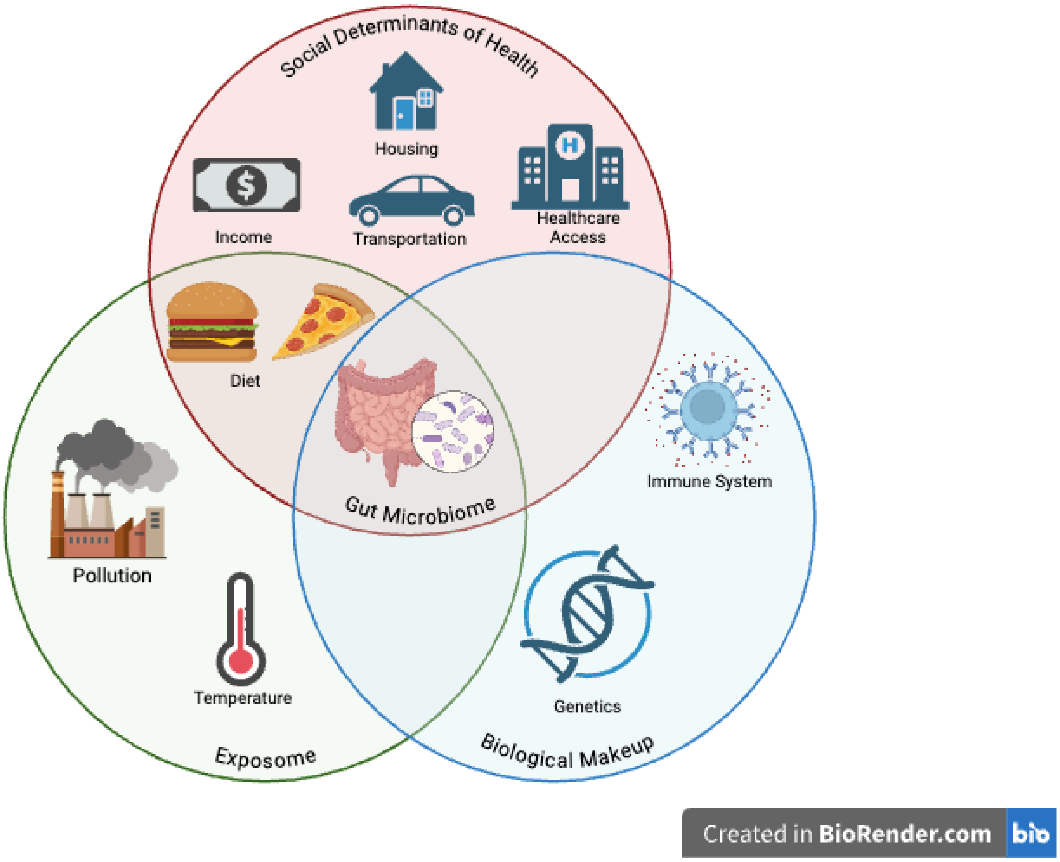


Figure 1: Contributing factors to IBD pathophysiology; created with BioRender.com; the various contributing factors to IBD pathophysiology are illustrated above. The exposome measures all environmental exposures an individual has experienced throughout their lifetime. Diet is a component of the external exposome that influences the internal exposome, namely the gut microbiome and the immune system. Genetic predisposition makes individuals more prone to developing IBD. The social determinants of health, such as housing, income level, access to transportation, and proximity to the hospital, all influence disease severity and patient outcomes.

This is particularly a problem given the prevalence of UPF and food insecurity (FI). Data from the CDC's 2023 National Health and Nutrition Examination Survey (NHANES) indicated that UPFs accounted for roughly 55.0% of the average American's total caloric intake (Narula et al., 2021). While food insecurity, defined as inconsistent and unreliable access to food necessary for an active, healthy life, affects 14% of the current population in the United States. In an analysis of the National Health Interview Survey carried out by the CDC, it was found that individuals with IBD face a higher risk of experiencing FI than the average US adult, with 14% of individuals with IBD in the US eligible for classification as food insecure (Gold et al., 2024; Baniqued et al., 2025).

Yet, FI is just one component of the Social Determinants of Health (SDoH) that influence IBD quality of care and health outcomes. SDoH, defined as the conditions in which people grow, live, learn, and work, are grouped into five categories: financial stability, access to quality education, quality healthcare, neighborhood environment, and community support (Chirayath et al., 2025; Figure 1). Of these factors, neighborhood socioeconomic disadvantage has been independently associated with 30-day mortality for patients with common gastrointestinal diseases, and lower socioeconomic status has also been linked to increased rates of outpatient visits in persons with IBD (Bernstein et al., 2020; Blass et al., 2025; Vrtikapa et al., 2025). Given the documented impacts of these structural inequalities on the health outcomes of IBD patients, recent research has focused on identifying their compounding effects alongside patient demographics and physiological symptoms to better track disease progression and healthcare utilization of IBD patients.

A study by Shah et al. (2022) used clinical charts and self-reported surveys from a major Texas hospital system to evaluate the effectiveness of incorporating SDoH, alongside disease extent and behavior, in IBD patients for predicting whether patients would need hospitalization or surgery (Shah et al., 2022). Although the model demonstrated that incorporating the SDoH improves the performance of predictive models, the fact that the majority of patients were insured and reported no financial, food security, or transportation concerns led to the conclusion that these factors have limited impact on the likelihood of adverse health outcomes.

While existing research demonstrates the effect of self-reported social barriers on predicting the need for inpatient care, there is a significant gap in the literature regarding the impact of structural disparities among different age and sex groups on IBD clinical severity. Accordingly, this study examines how county-level food-access disparities and local socioeconomic vulnerabilities affect the severity of inflammatory bowel disease across demographic groups in Texas.

2. Methods

The Texas Health Care Information Collection (THCIC) program was used to collect inpatient hospitalization records for the years 2016 and 2018. Patients were filtered based on the Major Diagnostic Category (MDC) and refined to include only Inflammatory Bowel Disease based on All-Patient Refined Diagnosis-Related Groups (APR-DRG). Each patient's age, race/ethnicity, and illness severity were compiled. The APR-DRG severity scale was used to quantify the patient's severity of illness, with 1 indicating Mild, 2 Moderate, 3 Major, and 4 Extreme.

Food insecurity data were obtained from the Feeding America dataset. County-level food insecurity rates and average meal costs were compiled for each calendar year. The percentage of food-insecure individuals with incomes below the federal or state eligibility limit for nutrition programs (typically 130% of the Federal Poverty Line) was also collected. Additionally, the percentage of food-insecure individuals with incomes above SNAP eligibility but within the range for other federal nutrition programs (typically 130-185% of the Federal Poverty Line) was included.

The analysis focused on the 2016 and 2018 retrospective cohorts to correspond to the CDC's Social Vulnerability Index (SVI) dataset, which is released biennially. The composite social vulnerability score and its four principal theme scores (Socioeconomic Status, Household Characteristics, Racial and Ethnic Minority Status, and Housing Type and Transportation) were compiled for all 254 counties in Texas. Socioeconomic Status (Theme 1) measures individuals in a county who are below the poverty level, unemployed, classified as low income, or without a high school diploma. Household Composition and Disability (Theme 2) captured household composition by accounting for residents aged 65 or older, those aged 17 or younger, civilians living with a disability, and single-parent households. Minority Status and

Language (Theme 3) evaluated the proportion of the population identifying as a minority, as well as the proportion of individuals who speak English "less than well." Finally, Housing Type and Transportation (Theme 4) assessed infrastructural vulnerabilities, including residents living in multi-unit structures, mobile homes, crowded housing, group quarters, or households without access to a vehicle.

Restricting the study period to 2016 and 2018 also excluded the 2020 dataset to avoid the potential clinical and healthcare utilization confounders introduced by the COVID-19 pandemic.

For each record acquired from the THCIC dataset, the patient's county of residence and data year were used to assign their county-level food insecurity and SDoH metrics. This data was used to run an ordinal logistic regression model in R to evaluate the effects of these multi-level demographic and socioeconomic factors on IBD disease severity.

3. Results

A total of 2,000 individuals who were hospitalized for IBD in the state of Texas in 2016 and 2018 were identified. Within this cohort, females represented 49.95% of the sample (n = 999), males represented 41.40% (n = 828), and 8.65% (n = 173) had an unidentified or unknown sex (Table 1a). Pediatric patients (ages 0-17) comprised 11.05% (n = 221) of the cohort. The primary age demographic of the sample was 18-44 years, at 34.45% (n = 689), while the middle-aged 45-64 years age group represented 27.50% of the sample (n = 550). Older demographics comprised 292 individuals aged 65 to 74 and 248 aged 75 and older, representing 14.60% and 12.40% of the population, respectively (Table 1a).

When evaluating baseline clinical severity, the majority of hospitalized individuals had moderate illness severity, accounting for 39.75% (n = 795). Extreme severity of illness was the least prevalent manifestation, accounting for 7.65% of the total cohort (n = 153). Additionally, 501 individuals (25.05%) presented with minor severity of illness, and 551 individuals (27.55%) with major severity of illness.

At the county level, the median percentage of food-insecure individuals with household incomes at or below their state's Supplemental Nutrition Assistance Program (SNAP) gross income limit was 35.40% (Table 1b). The median percentage of food-insecure individuals with household incomes above the SNAP gross income limit but within the federal gross income limit for other federal nutrition programs, such as WIC, was 2.93%. Across all 254 counties over two years, the median cost per meal was $2.87.

For overall county-level social vulnerability metrics, the overall median social vulnerability score across all categories was 0.5178 (Table 1b). When examining the stratified subgroups, the median score was 0.4308 for socioeconomic status (Theme 1), 0.3439 for household characteristics (Theme 2), 0.5534 for Racial and Ethnic Minority Status (Theme 3), and 0.5810 for Housing Type and Transportation (Theme 4). Patient demographics and county-level socioeconomic summary statistics are shown in Table 1a and Table 1b.

Table 1a. Patient demographics and severity of illness (n = 2000)

Demographic category	Patient count (n)	Percentage (%)
Sex		

Female	999	49.95%
Male	828	41.40%
Unknown	173	8.65%
Age		
0-17	221	11.05%
18-44	689	34.45%
45-64	550	27.50%
65-74	292	14.60%
75+	248	12.40%
APR-DRG illness severity		
Minor	501	25.05%
Moderate	795	39.75%
Major	551	27.55%
Extreme	153	7.65%

Table 1b. County-level environmental and socioeconomic medians

Metric	**Value**
% FI ≤ low threshold	Median: 35.40%
% FI between thresholds	Median: 2.93%
Cost per meal ($)	Median: $2.87
RPL Theme 1 (socioeconomic status)	Median: 0.4308
RPL Theme 2 (household characteristics)	Median: 0.3439
RPL Theme 3 (racial & ethnic minority status)	Median: 0.5534
RPL Theme 4 (housing type & transportation)	Median: 0.5810
RPL themes overall	Median: 0.5178

Note: Ranked Percentile (RPL) values range from 0 to 1, with higher values signifying greater vulnerability. % FI ≤ Low Threshold: percentage of food insecure individuals at or below SNAP income level. % FI Between Thresholds: percentage of food insecure individuals with incomes above SNAP eligibility but below WIC/other program levels.

Analysis of IBD severity (2016 and 2018)

The associations between county-level food insecurity, demographic factors, and IBD severity are summarized in Table 2.

Table 2. Odds ratios for predictors of increased IBD severity (2016 and 2018)

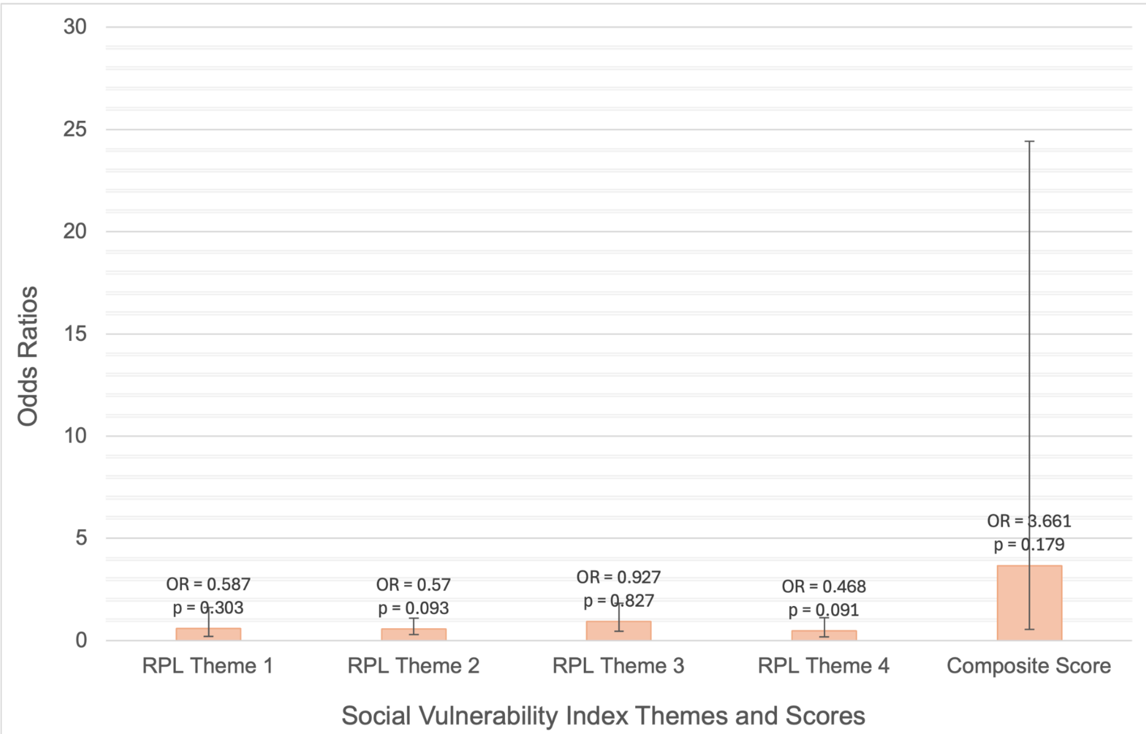
Predictor	Odds ratios (95% CI)	p-value
Food insecurity rate	1.034 (1.001, 1.067)	0.042*
% FI between thresholds	0.883 (0.824, 0.947)	<0.001*
% FI low threshold	1.001 (0.998, 1.004)	0.432
Cost per meal	1.16 (0.661, 2.033)	0.606
Age 18-44	0.842 (0.63, 1.125)	0.243
Age 45-64	1.066 (0.794, 1.433)	0.671
Age 65-74	1.461 (1.056, 2.021)	0.022*
Age 75+	2.087 (1.494, 2.919)	<0.001*
Sex M	1.002 (0.846, 1.188)	0.980
Sex F	0.998 (0.842, 1.182)	0.980
Sex unknown	1.184 (0.873, 1.605)	0.278

Note: **Statistically significant value with the p-value* < 0.05.

For 2016 and 2018, county-level food insecurity emerged as a statistically significant predictor of more severe manifestations of IBD, with a 3.4% increase in odds per 1% increase in food insecurity (OR = 1.034, p = 0.042) (Table 2). The percentage of food-insecure individuals at or below the state's SNAP gross income limit (165% of the Federal Poverty Level) was associated with slightly higher odds of greater IBD severity; the relationship was not significant (OR = 1.001, p = 0.432). In contrast, the percentage of food-insecure individuals with household incomes above the SNAP gross income limit but below the upper gross income threshold for alternative federal nutrition programs was significantly associated with lower odds of IBD severity (OR = 0.883, p < 0.001). Despite the slight increase in odds of greater illness severity, the average cost per meal demonstrated no significant impact (OR = 1.160, p = 0.606).

Beyond food insecurity metrics, age also appeared as a statistically significant predictor of patient severity of illness, with older age groups having a strong positive association with increased IBD severity compared to younger patients (Table 2). The geriatric cohort aged 75 years and above exhibited more than double the odds of experiencing increased IBD severity (OR = 2.087, $p < 0.001$). The 65-74-year age group exhibited a similarly significant positive association, although to a lesser extent, with an estimated 46% increase in the odds of heightened clinical severity (OR = 1.461, p = 0.022). Despite the weak correlation, the 45-64-year age group showed slightly higher odds of IBD severity (OR = 1.066, p = 0.671), while the 18-44-year age group showed lower odds of IBD severity (OR = 0.842, p = 0.243).

Graph 1. Association of SVI RPL Themes and the SVI Composite Score of a County with IBD Severity



Neither the composite social vulnerability score nor the four social vulnerability themes were statistically significant predictors of increased IBD severity (Graph 1). Measures of economic hardship and financial resilience, as represented by Theme 1 (Socioeconomic Status), were inversely associated with the severity of IBD (OR = 0.587, p = 0.303). Similarly, Theme 2, involving care dependency and household income sources, showed lower odds of severity, though not statistically significant (OR = 0.570, p = 0.093). The association between severity of illness and county-level racial and ethnic minority distributions (Theme 3) was close to an OR of 1 (p = 0.827). Neighborhood structural dynamics, such as housing density and transportation infrastructure (Theme 4), were associated with lower odds of extreme IBD presentation but were not statistically significant (OR = 0.468, p = 0.091). The aggregation of these themes yielded a county's composite SVI score, which was associated with three times higher odds of experiencing a more severe manifestation of disease. However, this was not statistically significant (OR = 3.661, p = 0.179) (Graph 1).

Finally, the association between clinical disease severity and patients' recorded sex was evaluated. Male patients had greater odds (OR = 1.002) of experiencing more severe IBD symptoms compared to female patients (OR = 0.998); however, neither finding was statistically significant. Interestingly, individuals whose sex was classified as "unknown" experienced greater odds of experiencing more severe IBD as well (OR = 1.184), though this finding was not statistically significant either (Table 2).

4. Discussion

In this cross-sectional study of adults hospitalized for IBD in Texas in 2016 and 2018, the correlation between food insecurity, income level, social vulnerability, and disease severity was analyzed. Individuals faced 3.4% higher odds of experiencing more severe manifestations of IBD for each percentage point increase in county-level food insecurity rates. A potential explanation is that food-insecure IBD patients are 27% more likely to consume ultra-processed foods and 29% less likely to consume unprocessed foods compared to those who are food-secure (Nguyen et al., 2020). Furthermore, cross-sectional analyses of the NHANES show that food insecurity is associated with 21% higher odds of elevated C-reactive protein (an inflammatory marker) and 36% higher odds of high white blood cell counts, demonstrating that the dietary patterns of food-insecure patients cause inflammation and immune overactivation (Gowda et al., 2012). An additional explanation includes that UPFs are also nutritionally deficient and may delay healing (Lobionda et al., 2019; Scaldaferri et al., 2017). The mucosal lining of the gastrointestinal tract becomes impaired due to nutritional inadequacy, increasing intestinal permeability and the immune response that causes IBD flares. Further consequences include prolonged hospitalization, infection, venous thromboembolism, and increased postoperative mortality (Kane et al., 2014; Michielan & D'Incà, 2015; Men et al., 2019). Malnutrition affects 65-75% of patients with Crohn's disease and 18-62% of patients with ulcerative colitis and thus this is a major concern for this population (Scaldaferri et al., 2017). Establishing this link, the study demonstrates that food access metrics can indicate geographic regions where hospitalized IBD patients are at increased risk of severe illness.

Another finding of this paper was the significant correlation between individuals qualifying for federal nutrition programs and IBD severity. The percentage of food-insecure individuals whose incomes fell above the SNAP gross income limit but within the upper threshold for alternate federal nutrition programs was significantly associated with lower odds of IBD severity (OR = 0.883, $p < .001$). These individuals are within the "SNAP gap," where household income exceeds the SNAP eligibility threshold yet food insecurity rates remain elevated at approximately 25% (Wentworth et al., 2018). Despite being food insecure, these households have somewhat greater financial resources than those at or below the SNAP threshold, which may buffer the most severe forms of nutritional deprivation. By contrast, the percentage of food-insecure individuals at or below the SNAP income threshold did not reach statistical significance (OR = 1.001, $p = 0.432$). This finding suggests an unprotective effect of SNAP participation, which is contrary to current disseminated information, as the program has been shown to reduce the likelihood of food insecurity by approximately 30% among enrolled households (Geanacopoulos et al., 2025).

Beyond food access, age emerged as one of the most significant predictors of IBD severity in the cohort. Patients aged 75 years and older had more than double the odds of experiencing more severe manifestations of IBD compared to the pediatric age group (OR = 2.087, $p < .001$). At the same time, the 65-74-year cohort exhibited a similarly significant positive association (OR = 1.461, $p = 0.022$). The results are consistent with the recorded growing global burden of IBD in older adults. The absolute number of elderly IBD cases more than doubled globally between 1990 and 2021, increasing from

573,500 to 1,278,190, and projections indicate that elderly IBD prevalence may reach 2,316,000 by 2051, with deaths and disability-adjusted life years projected to increase to 75,000 and 1,401,000, respectively (Liu et al., 2024). This pattern could be explained by elderly patients' immunosenescence, the gradual decline of the immune system that occurs with age, which results in the impaired function of dendritic cells, phagocytes, and natural killer cells (Berrut & de Decker, 2015). Dysfunction of these innate immune cells results in the gut microbiome secreting pro-inflammatory cytokines and mediators, which destroy tissue and create excessive fibrosis in the GI tract (Saez et al., 2023; Steinbach & Plevy, 2014). Ultimately, these age-related immune changes directly drive the heightened disease severity observed in older patients, as this study found.

In contrast to age and food insecurity, neither sex nor county-level social vulnerability achieved statistical significance as a predictor of IBD severity. This study found that males experience worse severity of illness compared to females, supporting prior findings that male patients are 42% more likely to require surgery than female patients (Rasmussen et al., 2024). Despite high odds ratios, the lack of statistical significance across nearly all social vulnerability scores is likely caused by healthcare utilization patterns. Because publicly insured patients have 2.82 times higher odds of high inpatient costs and 2.50 times higher odds of high emergency spending, while low-income IBD patients are 62% less likely to utilize outpatient services, the severity scores in administrative datasets become inflated (Park et al., 2014).

Limitations

The paper assumes that individuals included in the THCIC dataset are consistent across all datasets used in the study. The use of county-level data to represent individual patient experiences introduces potential for error, since aggregate measures may not accurately represent specific patients within those counties. Restricting the study period to 2016 and 2018 to exclude COVID-19-related healthcare disruptions limits the generalizability of these conclusions. The significant proportion of patients with unidentified or unknown sex also makes it difficult to assess the impact of sex on disease outcomes.

5. Conclusion

This study contributes a novel population-level perspective on the determinants of IBD severity in Texas, a state defined by geographic and demographic heterogeneity in food access and socioeconomic vulnerability. The study revealed that county-level food insecurity and advanced age significantly increase the odds of severe IBD presentation. Conversely, neither sex nor county-level social vulnerability measures could predict clinical severity. This emphasizes the need for IBD management to incorporate food-access screening into patient care. The incorporation of targeted nutritional interventions and assistance with navigating federal food assistance programs into IBD care pathways may represent a meaningful, actionable strategy for lessening the disparate burden of this severe chronic disease among vulnerable patient populations. Incorporating food access screenings into IBD treatments has the potential to reduce severe, resource-intensive hospitalizations among vulnerable patient populations.

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Data & Code Availability Statement

The dataset and R code used in this study are made available from the author and can be accessed at the following repository.

Acknowledgements

I would like to thank Dr. Barbara Biney for her support and invaluable guidance during the research process. Data were obtained from the Texas Health Care Information Collection Program, the CDC/ATSDR SVI databases, and the Feeding America Map the Meal Gap datasets. Graphics were created in BioRender, and charts were created in Excel.

Author Biography

Mentor Contribution Statement

Dr. Barbara Biney was a source of guidance for the process of identifying the appropriate statistical methodologies for the study variables and assisted in conducting the ordinal logistic regression analysis using RStudio. Additionally, she offered valuable feedback in reviewing and refining the manuscript.

Review of:
Impact of Regional Food Insecurity and Social Vulnerability on Inpatient IBD Severity in the State of Texas

Reviewer Guidelines for Convergence

1. **Key Evaluation Criteria**

- **Originality & Significance** – Does the paper contribute new insights or perspectives to the field?

This study examines an understudied question by linking county-level food insecurity and social vulnerability measures with inpatient IBD severity. While previous studies have focused primarily on individual-level social determinants of health, this manuscript explores structural, geographic determinants across an entire state, providing a unique perspective.

Strengths:

- Addresses an important public health issue.
- Uses statewide data rather than a single institution.
- Combines multiple publicly available datasets.
- Findings regarding county-level food insecurity have potential implications for screening and resource allocation.

Areas for improvement:

- The novelty should be stated more explicitly in the Introduction. The authors should clearly articulate how this work differs from previous studies evaluating social determinants in IBD rather than simply stating there is a "gap."
- The Discussion should better explain why county-level measures provide information beyond patient-level social determinants.

- **Clarity & Structure** – Is the argument well-organized and easy to follow? Are ideas clearly presented?

Overall the manuscript follows a logical structure and is easy to read.

Strengths:

- Clear organization.
- Appropriate flow from Introduction through Discussion.
- Tables are generally easy to interpret.

Suggestions:

Introduction

The Introduction is considerably longer than necessary.

Several paragraphs spend substantial space explaining IBD pathophysiology that is only loosely connected to the research question. The manuscript would benefit from shortening this section and focusing more directly on:

- food insecurity
- social determinants of health
- existing evidence
- remaining knowledge gaps
- study objectives

Methods

The Methods require additional detail for reproducibility.

Important information is missing, including:

- inclusion/exclusion criteria
- handling of missing data
- rationale for selecting exactly 2,000 patients
- whether multiple admissions from the same patient were included
- ICD coding strategy
- assumptions and diagnostics for ordinal logistic regression
- testing of the proportional odds assumption
- handling of collinearity between food insecurity and SVI variables

Results

The Results section is generally clear but could be improved by:

- reporting effect sizes consistently
- avoiding interpretation within the Results
- providing model fit statistics
- indicating which variables were included simultaneously in the regression model.

Discussion

Several paragraphs move beyond what the data actually demonstrate.

For example: "food insecurity causes inflammation" cannot be concluded from county-level observational analyses.

The Discussion should consistently distinguish between:

- observed associations
- biologically plausible explanations
- causal conclusions.

- **Use of Evidence & Research Methods** – Are sources appropriately cited? Is their methodology sound and well-explained?

This is the section requiring the greatest improvement.

Major methodological concerns:

Ecological inference

- The study assigns county-level variables to individual patients.
- The manuscript should explicitly discuss ecological fallacy.
- County-level food insecurity does **not** necessarily represent an individual patient's food security.

Confounding

Important clinical variables are absent. Potential confounders include:

- Crohn's disease vs ulcerative colitis
- comorbidities
- insurance status
- disease duration
- race/ethnicity
- hospital characteristics
- urban vs rural status

Without adjustment for these factors, interpretation of food insecurity effects is limited.

Regression model

The manuscript does not adequately describe:

- variable selection
- interaction testing
- multicollinearity assessment
- proportional odds testing
- goodness-of-fit

These should be reported.

Interpretation of Odds Ratios

Several statistically significant odds ratios are extremely close to 1. For example: OR = 1.034

While statistically significant, readers need discussion regarding whether this represents a clinically meaningful association.

- **Engagement with Literature** – Does the paper demonstrate an understanding of relevant research in the field? Do they acknowledge known results and connect their findings well to them?

The literature review is comprehensive and includes many recent references.

Strengths:

- Good use of recent literature (2024–2025).
- Demonstrates familiarity with food insecurity literature.
- Connects findings with previous IBD research.

Suggestions: Some comparisons are overstated. For example, statements suggesting SNAP participation is ineffective should be interpreted much more cautiously because the study did **not** evaluate individual SNAP participation. Likewise, explanations involving immunosenescence, microbiome changes, and inflammatory mechanisms are plausible but remain speculative given the available data.

The authors should separate mechanistic hypotheses from study findings.

- **Grammar & Language** – Is the writing clear and professional? Minor grammatical and stylistic errors should be noted, but they should not be the main focus of the review.

Minor suggestions:

2. Reduce repetition of phrases such as "greater odds of experiencing more severe manifestations."
3. Shorten lengthy sentences in the Introduction.
4. Use consistent terminology:
    a. food insecurity
    b. food-access disparities
    c. social vulnerability
5. Ensure consistent formatting of p-values.
6. Define all abbreviations at first use (APR-DRG, RPL, etc.).
7. Verify consistency in SNAP eligibility thresholds. The manuscript references both **130% FPL** and **165% FPL**, which appears inconsistent.

8. **Ethical and Logistical Considerations**

- The study appears ethically appropriate because it relies on secondary administrative datasets.

Final Recommendation

- Minor revision- This manuscript addresses an important research question and has the potential to make a meaningful contribution to understanding structural determinants of IBD severity. The statewide dataset and integration of food insecurity and social vulnerability measures are notable strengths.

  However, several revisions are needed before the findings can be fully evaluated. The Methods require considerably more detail to ensure reproducibility, the statistical analyses need additional justification and reporting, and several interpretations should be tempered to avoid causal language that is not supported by the observational, county-level design. Addressing these issues would substantially strengthen the rigor and impact of the manuscript.

Impact of Regional Food Insecurity and Social Vulnerability on Inpatient IBD Severity in the State of Texas – Submission 100208

Thank you for the opportunity for me to review, “Impact of Regional Food Insecurity and Social Vulnerability on Inpatient IBD Severity in the State of Texas.” I am impressed by the quality of work and analysis completed by a high school student. I have added some suggestions below to further improve the paper.

Title:

- Do not use acronyms in title “IBD”
- Consider shortening your title by removing the location and adding the type of study instead. E.g. “Impact of Regional Food Insecurity and Social Vulnerability on Irritable Bowel Disease Severity: Dataset analysis”

Abstract:

Well written, succinctly abstract that summarizes the study well.

- remove acronym “SNAP” or expand on this
- same with “SVI” and “CDC”
- remove last semi-colon, line 33

Introduction:

Concise summary of the literature. Research gap and research question is clearly stated at the end.

- how can a 2015 paper state the total cost of IBD in 2025? Line 38, “…total healthcare costs in 2025 were estimated to be around $25,243,078,919 (Coward et al., 2015).”
- Expand “GI”, line 44. Read through your paper and expand all acronyms that first appear. Do not use an acronym for words repeated less than 3 times. Consider the Abstract and the rest of the paper as separate sections so your acronyms need to be re-expanded.
- Briefly explain “dysbiosis” as this is a general audience journal, line 48

Methods:

Good description of the dataset and explanation for why 2020 was omitted.

- Explain how you obtained the datasets. Was it publicly available data? Did you need to request permission for access and use? Explicitly state your connection with the data and whether or not IRB approval was needed.
- Cite R, line 110

Results:

Thorough summary of participant demographics. Results are presented well.

- State how severity was measured, if data is available, lines 110-122.
- Keep consistent decimal places throughout the paper, lines 128-132 has 4 decimal places while some of the paper uses 2 and others use 3. In this same section, explain/describe what these scores mean. My recommendation is to use 2 decimal places throughout.
- Use the same font throughout the paper, lines 136-139

Discussion:

- Explain your ORs for other findings as you did in the results section like how you did in lines 145, 178-179.
- Explain in terms other students who have no stats background can understand when you say “inverse” correlation and “positive association”
- Limitations: were models ran for accounting for missing data? Were all assumptions of an ordinal regression met? If not, a statement should be put here to let readers know that these results should be interpreted with caution.

Conclusion:

- Line 234, “…severe IBD presentation [in our sampled population].”
- Italicize issue numbers

Formatting/References:

- Title all figures, graphs and tables at the top. Write “Note” if an explanation is needed at the bottom (see APA style)

Decision: Accept with minor revisions

Convergence
A Journal for Young Researchers

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Action Editor: [for official use only]

Impact of Regional Food Insecurity and Social Vulnerability on Inflammatory Bowel Disease Severity: A Cross-Sectional Analysis

Abstract

Inflammatory Bowel Disease (IBD) is an autoimmune disorder involving chronic inflammation of the gastrointestinal tract. While research has linked ultra-processed food consumption to its pathophysiology, the role of food access on the severity of IBD remains understudied. This cross-sectional study of Texas inpatient hospitalization data evaluated how county-level food access and social vulnerabilities affect IBD severity. Records of 2,000 adults hospitalized for IBD in 2016 and 2018 were merged with county-level data from the Feeding America and Centers for Disease Control's Social Vulnerability Index datasets. An ordinal logistic regression model assessed predictors of clinical severity using All-Patient Refined Diagnosis-Related Groups scores. The county-level food insecurity rate was a significant predictor of higher clinical severity (OR = 1.03, $p = 0.04$). Conversely, individuals with low income who do not qualify for Supplemental Nutrition Assistance Program (SNAP) or other federal nutrition programs exhibited lower odds of severe illness (OR = 0.88, $p < 0.001$). Advanced age was also a strong predictor, while neither sex nor composite SVI markers reached statistical significance. Overall, these findings identify regional food insecurity as a social determinant of health strongly associated with increased clinical severity of IBD, demonstrating that food access affects clinical outcomes at admission.

Keywords:

Medicine;Inflammatory Bowel Disease; Social Determinants of Health; Food Insecurity;

1. Introduction

Inflammatory Bowel Disease (IBD) encompasses Crohn's Disease and Ulcerative Colitis, two chronic, immune-mediated conditions characterized by relapsing inflammation of the gastrointestinal (GI) tract (Fakhoury et al., 2014; Reddavide et al., 2018). Since 2015, IBD prevalence in the United States has been increasing by 1.72%. With 0.7% of Americans having IBD, Coward et al. projected that total U.S. healthcare costs for IBD would reach $25,243,078,919 by 2025 (Coward et al., 2015).

While the exact etiology of IBD remains unknown, it is widely accepted to involve immunological, environmental, physiological, and psychosocial factors that trigger genetic predispositions and alter the gut microbiome (Figure 1). The exposome, the total lifetime burden of environmental exposures, is one such factor (Coward et al., 2015). These exposures trigger abnormal immune responses in the GI tract and cause chronic dysbiosis, an imbalance in the gut microbiome that disrupts normal digestion and creates a pro-inflammatory environment (Figure 1).

One major component of the exposome that influences IBD onset and prognosis is diet, as high consumption of ultra-processed foods (UPFs) is associated with increased IBD risk (Abegunde et al., 2016). Food insecurity (FI), defined as inconsistent and unreliable access to food necessary for an active, healthy life, is another component. Both contribute to the chronic nutritional deficiencies that perpetuate dysbiosis in IBD. This impairs the mucosal lining of the GI tract, increasing intestinal permeability to pathogens and amplifying the immune response that drives chronic inflammation in IBD patients (Nguyen & Bollegala, 2014; Nguyen et al., 2020).

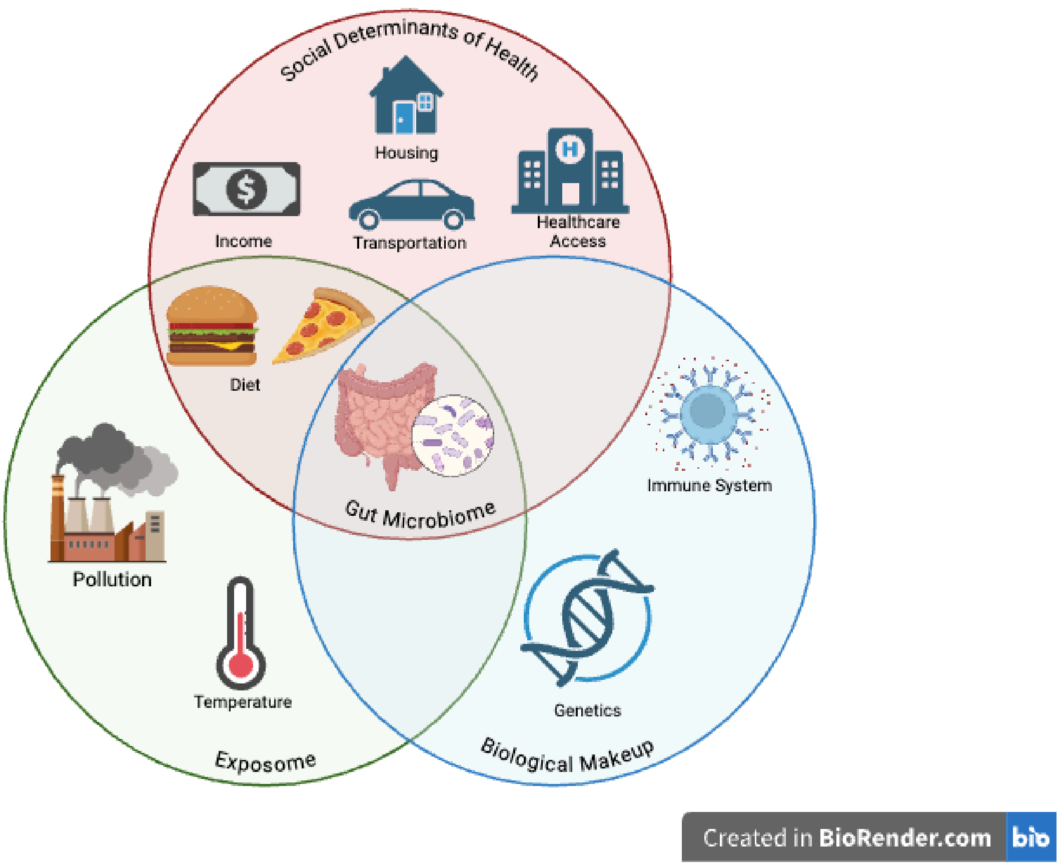


Figure 1: Contributing factors to IBD pathophysiology; created with BioRender.com; the various contributing factors to IBD pathophysiology are illustrated above. The exposome measures all environmental exposures an individual has experienced throughout their lifetime. Diet is a component of the external exposome that influences the internal exposome, namely the gut microbiome and the immune system. Genetic predisposition makes individuals more prone to developing IBD. The social determinants of health, such as housing, income level, access to transportation, and proximity to the hospital, all influence disease severity and patient outcomes.

The widespread prevalence of FI and consequent UPF consumption raises concerns about gastrointestinal health in the IBD population. Data from the Centers for Disease Control and Prevention's (CDC) 2023 National Health and Nutrition Examination Survey (NHANES) indicated that UPFs accounted for roughly 55.0% of the average American's total caloric intake (Narula et al., 2021). FI also affects 11-14% of the current population in the United States. In an analysis of the National Health Interview Survey carried out by the CDC, it was found that individuals with IBD face a higher risk of experiencing FI than the average US adult, with 14% of individuals with IBD in the US eligible for classification as food insecure (Gold et al., 2024; Baniqued et al., 2025).

Yet, FI is just one component of the Social Determinants of Health (SDoH) that influence IBD quality of care and health outcomes. The SDoH is defined as the conditions in which people grow, live, learn, and work. It is grouped into five categories: financial stability, access to quality education, quality healthcare, neighborhood environment, and community support (Chirayath et al., 2025; Figure 1). Of these factors, neighborhood socioeconomic disadvantage has been independently associated with 30-day mortality for patients with common gastrointestinal diseases, and lower socioeconomic status has also been linked to increased rates of outpatient visits in persons with IBD (Vrtikapa et al., 2025; Clark et al., 2025). Given the documented impacts of these structural inequalities on the health outcomes of IBD patients, recent research has focused on identifying their compounding effects alongside patient demographics and physiological symptoms to better track disease progression and healthcare utilization of IBD patients.

A study by Shah et al. (2022) used clinical charts and self-reported surveys from a major Texas hospital system to evaluate the effectiveness of incorporating SDoH, alongside disease extent and behavior, in IBD patients for predicting whether patients would need hospitalization or surgery (Shah et al., 2022). Although the model demonstrated that incorporating the SDoH improves the performance of predictive models, the fact that the majority of patients were insured and reported no financial, food security, or transportation concerns led to the conclusion that these factors have limited impact on the likelihood of adverse health outcomes.

Prior research relied on self-reported measures within a single institution, limiting generalizability. Publicly available, county-level indicators that capture structural food-access conditions and social vulnerabilities independent of individual recall allow for a more objective evaluation of their association with IBD severity. Accordingly, this study examines how food-access disparities and socioeconomic vulnerabilities affect the severity of inflammatory bowel disease across demographic groups in Texas.

2. Methods

The Texas Health Care Information Collection (THCIC) program was used to collect inpatient hospitalization records for the years 2016 and 2018. Since these are publicly available secondary data that are de-identified, no IRB approval was required. Patients were filtered based on the Major Diagnostic Category for digestive diseases and refined to include only Inflammatory Bowel Disease based on All-Patient Refined Diagnosis-Related Groups (APR-DRG); ICD-9 or ICD-10 diagnosis codes were not used. Records with unknown or missing county of residence were excluded, yielding a final cohort of 2,000 patients. As county-level food access metrics also vary by year, hospitalizations from 2016 and 2018 were treated as independent records despite the possibility that the same patient may have been admitted both years. Patients with an unknown recorded sex were retained as a separate category because they represented a substantial population of the cohort. Each patient's sex, age group, county of residence, and illness severity were compiled. The APR-DRG severity scale was used to quantify the patient's severity of illness, with 1 indicating Mild, 2 Moderate, 3 Major, and 4 Extreme.

Food insecurity data were obtained through a direct request to the Feeding America organization to acquire their Map the Meal Gap datasets. County-level food insecurity rates and average meal costs were compiled for each calendar year. The percentage of food-insecure individuals with incomes below the federal or state eligibility limit for nutrition programs (165% of the Federal Poverty Line for the state of Texas) was also collected. Additionally, the percentage of food-insecure individuals with incomes above SNAP eligibility but within the range for other federal nutrition programs (within 165-185% of the Federal Poverty Line for the state of Texas) was included.

The analysis focused on the 2016 and 2018 retrospective cohorts to correspond to the CDC and Agency for Toxic Substances and Disease Registry's Social Vulnerability Index (SVI) dataset, which is released biennially and publicly accessible. The composite social vulnerability score and its four principal theme scores (Socioeconomic Status, Household Characteristics, Racial and Ethnic Minority Status, and Housing Type and Transportation) were compiled for all 254 counties in Texas. Socioeconomic Status (Theme 1) measures individuals in a county who are below the poverty level, unemployed, classified as low income, or without a high school diploma. Household Composition and Disability (Theme 2) captured household composition by accounting for residents aged 65 or older, those aged 17 or younger, civilians living with a disability, and single-parent households. Minority Status and Language (Theme 3) evaluated the proportion of the population identifying as a minority, as well as the proportion of individuals who speak English "less than well." Finally, Housing Type and Transportation (Theme 4) assessed infrastructural vulnerabilities, including residents living in multi-unit structures, mobile homes, crowded housing, group quarters, or households without access to a vehicle.

Restricting the study period to 2016 and 2018 also excluded the 2020 dataset to avoid the potential clinical and healthcare utilization confounders introduced by the COVID-19 pandemic.

For each record acquired from the THCIC dataset, the patient's county of residence and data year were used to assign their county-level food insecurity and SDoH metrics. This data was used to run an ordinal logistic regression model in R (version 4.5.2; R Core Team, 2025) using the ordinal package to evaluate the effects of these multi-level demographic and socioeconomic factors on IBD disease severity. Model fit was assessed using a likelihood ratio test against the null model and Nagelkerke's pseudo R^2 using the *rcompanion* package. The proportional odds assumption was tested using the Brant test through the MASS and *brant* packages. A pairwise correlation check was conducted for all continuous predictors. Finally, the p-value and odds ratio of the independent variables were evaluated using the AER package.

All food insecurity, demographic, and social vulnerability variables were selected based on their established relevance to IBD severity in existing research, rather than chosen after seeing the results. They were entered simultaneously into a single model, and interaction terms between variables were not tested.

3. Results

A total of 2,000 individuals who were hospitalized for IBD in the state of Texas in 2016 and 2018 were identified. Within this cohort, females represented 49.95% of the sample (n = 999), males represented 41.40% (n = 828), and 8.65% (n = 173) had an unidentified or unknown sex (Table 1a). Pediatric patients (ages 0-17) comprised 11.05% (n = 221) of the cohort. The primary age demographic of the sample was 18-44 years, at 34.45% (n = 689), while the middle-aged 45-64 years age group represented 27.50% of the sample (n = 550). Older demographics comprised 292 individuals aged 65 to 74 and 248 aged 75 and older, representing 14.60% and 12.40% of the population, respectively (Table 1a).

When evaluating baseline clinical severity using the APR-DRG scale described above, the majority of hospitalized individuals had moderate illness severity, accounting for 39.75% (n = 795). Extreme severity of illness was the least prevalent manifestation, accounting for 7.65% of the total cohort (n = 153). Additionally, 501 individuals (25.05%) presented with minor severity of illness, and 551 individuals (27.55%) with major severity of illness.

At the county level, the median percentage of food-insecure individuals with household incomes at or below their state's Supplemental Nutrition Assistance Program (SNAP) gross income limit was 35.40% (Table 1b). The median percentage of food-insecure individuals with household incomes above the SNAP gross income limit but within the federal gross income limit for other federal nutrition programs, such as the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), was 2.93%. Across all 254 counties over two years, the median cost per meal was $2.87.

For overall county-level social vulnerability metrics, the overall median social vulnerability score across all categories was 0.52, where higher values indicate greater vulnerability (Table 1b). When examining the stratified subgroups, the median score was 0.43 for socioeconomic status (Theme 1), 0.34 for household characteristics (Theme 2), 0.55 for Racial and Ethnic Minority Status (Theme 3), and 0.58 for Housing Type and Transportation (Theme 4). Patient demographics and county-level socioeconomic summary statistics are shown in Table 1a and Table 1b.

Table 1a. Patient demographics and severity of illness (n = 2000)

Demographic category	Patient count (n)	Percentage (%)
Sex		
Female	999	49.95%
Male	828	41.40%
Unknown	173	8.65%
Age		
0-17	221	11.05%
18-44	689	34.45%
45-64	550	27.50%

65-74	292	14.60%
75+	248	12.40%
APR-DRG illness severity		
Minor	501	25.05%
Moderate	795	39.75%
Major	551	27.55%
Extreme	153	7.65%

Table 1b. County-level environmental and socioeconomic medians

Metric	Value
% FI ≤ low threshold	Median: 35.40%
% FI between thresholds	Median: 2.93%
Cost per meal ($)	Median: $2.87
RPL Theme 1 (socioeconomic status)	Median: 0.43
RPL Theme 2 (household characteristics)	Median: 0.34
RPL Theme 3 (racial & ethnic minority status)	Median: 0.55
RPL Theme 4 (housing type & transportation)	Median: 0.58
RPL themes overall	Median: 0.52

Note: Ranked Percentile (RPL) values range from 0 to 1, with higher values signifying greater vulnerability. % FI ≤ Low Threshold: percentage of food insecure individuals at or below SNAP income level. % FI Between Thresholds: percentage of food insecure individuals with incomes above SNAP eligibility but below WIC/other program levels.

Analysis of IBD severity (2016 and 2018)

The associations between county-level food insecurity, demographic factors, and IBD severity are summarized in Table 2. All predictors were entered simultaneously into a single ordinal logistic regression. There was a significantly improved fit over the null model (likelihood ratio $\chi^2 = 76.50$, df = 15, $p < 0.001$), though the proportion of variance explained was modest (Nagelkerke's pseudo $R^2 = 0.041$).

Table 2. Odds ratios for predictors of increased IBD severity (2016 and 2018)

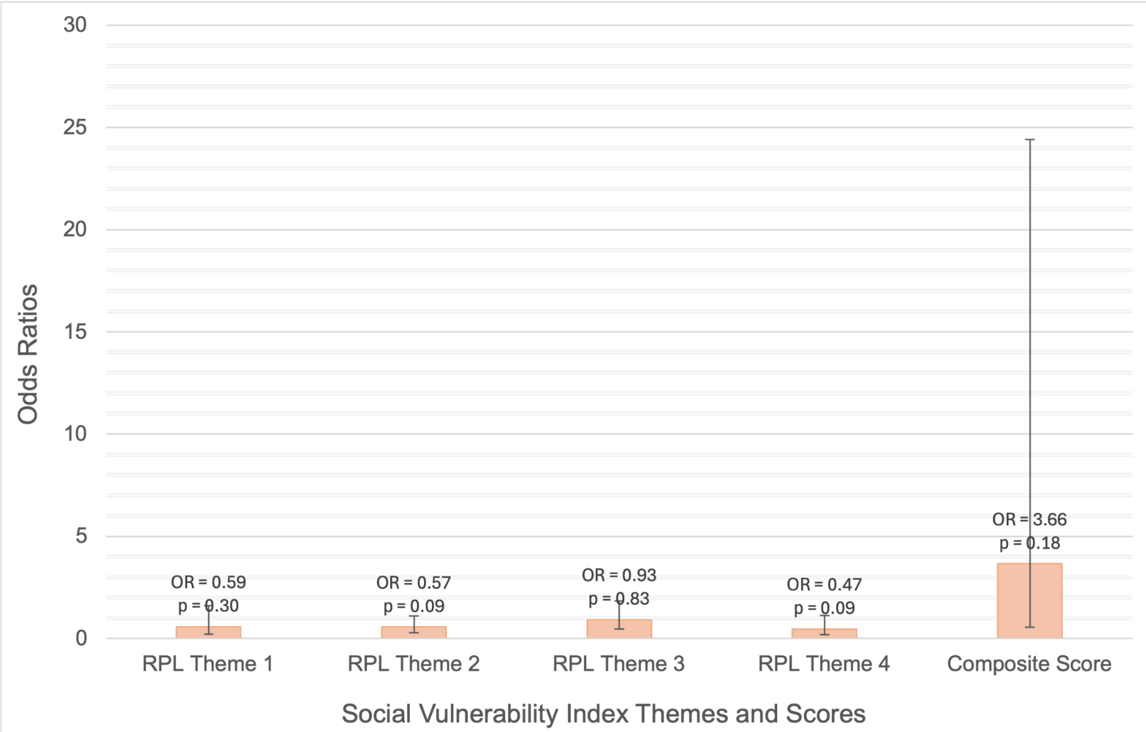
Predictor	Odds ratios (95% CI)	p-value
Food insecurity rate	1.03 (1.00, 1.07)	0.040*
% FI between thresholds	0.88 (0.82, 0.95)	<0.001*
% FI low threshold	1.00 (0.99, 1.00)	0.43
Cost per meal	1.16 (0.66, 2.03)	0.61
Age 18-44	0.84 (0.63, 1.13)	0.24
Age 45-64	1.07 (0.79, 1.43)	0.67
Age 65-74	1.46 (1.06, 2.02)	0.02*
Age 75+	2.09 (1.49, 2.92)	<0.001*
Sex M	1.00 (0.85, 1.19)	0.98
Sex F	1.00 (0.84, 1.18)	0.98
Sex unknown	1.18 (0.87, 1.61)	0.28

Note: **Statistically significant value with the p-value* < 0.05.

For 2016 and 2018, county-level food insecurity emerged as a statistically significant predictor of more severe manifestations of IBD, with a 3.40% increase in odds per 1% increase in food insecurity (OR = 1.03, $p = 0.04$) (Table 2). The percentage of food-insecure individuals at or below the state's SNAP gross income limit (165% of the Federal Poverty Level) showed a negligible, non-significant association with IBD severity ($p = 0.43$). In contrast, the percentage of food-insecure individuals with household incomes above the SNAP gross income limit but below the upper gross income threshold for alternative federal nutrition programs was significantly associated with lower odds of IBD severity (OR = 0.88, $p < 0.001$). Despite the slight increase in odds of greater illness severity, the average cost per meal demonstrated no significant impact (OR = 1.16, $p = 0.61$).

Beyond food insecurity metrics, age also appeared as a statistically significant predictor of patient severity of illness, with older age groups having a strong positive association with increased IBD severity compared to younger patients, meaning the odds of severe illness rose as age increased (Table 2). The geriatric cohort aged 75 years and above exhibited more than double the odds of experiencing increased IBD severity (OR = 2.09, $p < 0.001$). The 65 to 74-year age group exhibited a similarly significant positive association, although to a lesser extent, with an estimated 46% increase in the odds of heightened clinical severity (OR = 1.46, $p = 0.02$). The 45 to 64-year age group showed slightly higher odds of IBD severity (OR = 1.07, $p = 0.67$), while the 18-44-year age group showed lower odds of IBD severity (OR = 0.84, $p = 0.24$).

Graph 1. Association of SVI RPL Themes and the SVI Composite Score of a County with IBD Severity



Neither the composite social vulnerability score nor the four social vulnerability themes were statistically significant predictors of increased IBD severity (Graph 1). Measures of economic hardship and financial resilience, as represented by Theme 1 (Socioeconomic Status), was inversely associated with the severity of IBD, meaning higher socioeconomic vulnerability corresponded to lower odds of severe illness in this sample (OR = 0.59, p = 0.30). Similarly, Theme 2, involving care dependency and household income sources, showed lower odds of severity; this was not statistically significant (OR = 0.57, p = 0.09). The association between severity of illness and county-level racial and ethnic minority distributions (Theme 3) was close to an OR of 1 (p = 0.83). Neighborhood structural dynamics, such as housing density and transportation infrastructure (Theme 4), were associated with lower odds of extreme IBD presentation but were not statistically significant (OR = 0.47, p = 0.09). The aggregation of these themes yielded a county's composite SVI score, which was associated with three times higher odds of experiencing a more severe manifestation of disease; however, this was not statistically significant (OR = 3.66, p = 0.18) (Graph 1).

Finally, the association between clinical disease severity and patients' recorded sex was evaluated. Male patients had marginally higher odds of more severe IBD than female patients, though the difference was negligible and not statistically significant. Individuals whose sex was classified as "unknown" experienced somewhat greater odds of more severe IBD (OR = 1.18), though this finding was not statistically significant either (Table 2).

The proportional odds assumption was tested using the Brant test and requires each predictor's effect on IBD severity to be consistent across all severity thresholds. In this case, that is between Mild and Moderate, between Moderate and Severe, and between Severe and

Very Severe. The omnibus test indicated an overall violation of this assumption ($\chi^2 = 68.93$, df = 30, $p < 0.001$). The specific variables that contributed to this violation at the $p < 0.05$ level were Socioeconomic Status (Theme 1), the composite SVI score, Age 75+, and the percentage of food-insecure individuals between thresholds.

4. Discussion

In this cross-sectional study of adults hospitalized for IBD in Texas in 2016 and 2018, the association between food insecurity, income level, social vulnerability, and disease severity was analyzed. Individuals with IBD have 3.40% higher odds of experiencing more severe illness for each percentage-point increase in county-level food insecurity rates. On its own, this increased likelihood appears to be small. However, because odds ratios compound multiplicatively, this effect grows substantially across counties. The range of food insecurity rates observed in Texas counties spanned from 4.90% to 24.00% in this dataset, a difference of roughly 19.10 percentage points. This corresponds to a maximum compounded odds ratio of 1.89, or nearly 89.40% higher odds of severe IBD, when comparing a county with a low food insecurity rate to a county with a high food insecurity rate. Because county-level indicators do not depend on individual patients accurately recalling or disclosing their own food security status, they can be applied uniformly across an entire hospitalized population, including patients whose individual social history was incompletely documented, offering a scalable screening signal that patient-level, self-reported data alone cannot provide.

As this study measured food insecurity at the county level rather than for individual patients, the following mechanistic explanations from individual-level literature offer a plausible explanation for the findings of this study. Food-insecure IBD patients are 27% more likely to consume ultra-processed foods and 29% less likely to consume unprocessed foods compared to those who are food-secure (Nguyen et al., 2020). Furthermore, cross-sectional analyses of the NHANES show that food insecurity is associated with 21% higher odds of elevated C-reactive protein (an inflammatory marker) and 36% higher odds of high white blood cell counts, demonstrating that the dietary patterns of food-insecure patients cause inflammation and immune overactivation (Gowda et al., 2012). An additional explanation includes that UPFs are also nutritionally deficient and may delay healing (Lobionda et al., 2019; Scaldaferri et al., 2017). The mucosal lining of the gastrointestinal tract becomes impaired due to nutritional inadequacy, increasing intestinal permeability and the immune response that causes IBD flares. Further consequences include prolonged hospitalization, infection, venous thromboembolism, and increased postoperative mortality (Kane et al., 2014; Michielan & D'Incà, 2015; Men et al., 2019). Malnutrition affects 65-75% of patients with Crohn's disease and 18-62% of patients with ulcerative colitis and thus this is a major concern for this population (Scaldaferri et al., 2017). Taken together, these findings suggest that county-level food access metrics may help identify geographic regions where hospitalized IBD patients face elevated risk of severe illness, warranting further individual-level investigation to confirm the mechanisms proposed above.

The percentage of food-insecure individuals whose incomes fell above the SNAP gross income limit but within the upper threshold for alternate federal nutrition programs was significantly associated with lower odds of IBD severity. These individuals are within the "SNAP gap," where household income exceeds the SNAP eligibility threshold yet food insecurity rates remain elevated at approximately 25% (Wentworth et al., 2018). However, they still qualify for other federal nutrition assistance programs like WIC. Despite being food insecure, these households have somewhat greater financial resources than those at or below the SNAP threshold, and their continued eligibility for other federal nutrition programs may help buffer severe nutritional deprivation. By contrast, the percentage of food-insecure individuals at or below the SNAP income threshold did not reach statistical significance. This finding should not be interpreted as evidence that SNAP participation is ineffective, since this study measured county-level income eligibility for SNAP, not whether individual patients were actually enrolled in or received SNAP benefits. Prior individual-level research has shown that SNAP enrollment reduces the likelihood of food insecurity by approximately 30% among enrolled households (Ratcliffe et al., 2011; Geanacopoulos et al., 2025); the null finding here more likely reflects the limits of using an eligibility threshold as a proxy for program participation than any conclusion about SNAP's effectiveness.

Beyond food access, age emerged as one of the most significant predictors of IBD severity in the cohort. Patients aged 75 years and older had more than double the odds of severe illness relative to the pediatric age group. The 65 to 74-year cohort showed a similarly significant, though smaller, increase in odds. The results are consistent with the recorded growing global burden of IBD in older adults. The absolute number of elderly IBD cases more than doubled globally between 1990 and 2021, increasing from 573,500 to 1,278,190. Projections indicate that elderly IBD prevalence may reach 2,316,000 by 2051. Deaths and disability-adjusted life years were also estimated to increase to 75,000 and 1,401,000, respectively, by 2051. (Liu et al., 2024). This pattern could be explained by elderly patients' immunosenescence, the gradual decline of the immune system that occurs with age, which results in the impaired function of dendritic cells, phagocytes, and natural killer cells (Berrut & de Decker, 2015). Dysfunction of these innate immune cells results in the gut microbiome secreting pro-inflammatory cytokines and mediators, which destroy tissue and create excessive fibrosis in the GI tract (Saez et al., 2023; Steinbach & Plevy, 2014). While this study cannot confirm that immunosenescence drives the age-related severity pattern observed here, it remains a biologically plausible explanation consistent with the broader literature.

In contrast to age and food insecurity, neither sex nor county-level social vulnerability achieved statistical significance as a predictor of IBD severity. This study found that male patients had marginally higher odds of more severe illness than female patients despite the lack of significance, a direction consistent with prior findings that male IBD patients are 42% more likely to require surgery than female patients (Rasmussen et al., 2024). Similarly, despite comparatively high odds ratios for several social vulnerability measures, none reached statistical significance. One possible contributor is variation in healthcare utilization patterns across socioeconomic groups. Publicly insured patients have been shown to have 2.82 times higher odds of high inpatient costs and 2.50 times higher odds of high emergency spending, while low-income IBD patients are 62% less likely to use outpatient services (Park et al., 2014). This pattern could distort severity scores recorded in administrative datasets like the one used here. As such, the role of insurance and income in social vulnerability should be treated as a hypothesis for future research rather than an established cause of the null findings.

Limitations

The paper assumes that individuals included in the THCIC dataset are consistent across all datasets used in the study. Because food insecurity and social vulnerability were measured at the county level and assigned to individual patients based on county of residence, this study is subject to the ecological fallacy. It is the risk that relationships observed at the group level do not necessarily hold for individuals within that group (Robinson, 1950/2009). County-level food insecurity does not necessarily reflect whether any given hospitalized patient was personally food insecure, and this limitation should be kept in mind when interpreting all food insecurity and social vulnerability findings reported here.

No formal statistical model was used to account for missing data in this study. Records with missing county of residence were excluded from the analysis and patients with unknown recorded sex were retained as their own category since they represented a substantial part of the cohort. As no formal missing-data model, such as multiple imputations, were applied, the extent to which excluded or unknown records differ systematically from the analyzed cohort cannot be ruled out.

Several important variables were not available in this dataset and could not be adjusted for, including whether patients had Crohn's disease or ulcerative colitis, comorbidities, insurance status, disease duration, race/ethnicity, hospital characteristics, and urban versus rural residence. The absence of these variables limit the ability to isolate the independent effect of food insecurity and social vulnerability from other factors that plausibly influence IBD severity.

A pairwise correlation check identified substantial collinearity between the composite SVI score and two of its component themes, Socioeconomic Status and Housing Type and Transportation. This is likely due to the fact that composite score is mathematically derived from its component themes. Since the composite score and its individual themes were included in the same regression model, collinearity may have inflated standard errors and reduced the ability to detect true associations for these variables. It may also explain why none of the social vulnerability measures reached statistical significance despite several large odds ratios. Additionally, the proportional odds assumption was violated overall and for four individual predictors: Socioeconomic Status (Theme 1), the composite SVI score, Age 75+, and the percentage of food-insecure individuals between thresholds. For Socioeconomic Status (Theme 1) and the composite SVI score, the proportional odds violation likely reflects the collinearity between these two variables described above. For Age 75+ and the percentage of food-insecure individuals between thresholds, the violation is not explained by collinearity and instead suggests these variables' true effects on IBD severity differ across thresholds. For example, potentially having a stronger influence on the transition from severe to very severe illness than on the transition from mild to moderate illness. In both cases, the single odds ratio reported in Table 2 should be understood as an average effect across thresholds rather than a uniform one.

5. Conclusion

This study contributes a novel population-level perspective on the determinants of IBD severity in Texas, a state defined by geographic and demographic heterogeneity in food access and socioeconomic vulnerability. The study revealed that county-level food insecurity and advanced age were significantly associated with increased odds of severe IBD presentation in our sampled population. Conversely, neither sex nor county-level social vulnerability measures were significant predictors of clinical severity in this sample. These findings suggest a potential role for incorporating food-access screening into IBD patient care. Pairing such screening with targeted nutritional interventions and assistance navigating federal food assistance programs may represent a meaningful, actionable strategy for lessening the disparate burden of this severe chronic disease among vulnerable patient populations, potentially reducing severe, resource-intensive hospitalizations.

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Data & Code Availability Statement

The dataset and R code used in this study are made available from the author and can be accessed at the following repository.

Acknowledgements

I would like to thank Dr. Barbara Biney for her support and invaluable guidance during the research process. Data were obtained from the Texas Health Care Information Collection Program, the CDC/Agency for Toxic Substances and Disease Registry SVI databases, and the Feeding America Map the Meal Gap datasets. Graphics were created in BioRender, and charts were created in Excel.

Author Biography

Mentor Contribution Statement

Dr. Barbara Biney was a source of guidance for the process of identifying the appropriate statistical methodologies for the study variables and assisted in conducting the ordinal logistic regression analysis using RStudio. Additionally, she offered valuable feedback in reviewing and refining the manuscript.

TITLE

- Changed from "Impact of Regional Food Insecurity and Social Vulnerability on Inpatient IBD Severity in the State of Texas" to "Impact of Regional Food Insecurity and Social Vulnerability on Inflammatory Bowel Disease: A Cross-Sectional Analysis."

ABSTRACT

- Expanded acronyms.

INTRODUCTION EDITS

- Led with the general etiological factors of IBD before narrowing to the exposome as one specific factor.
- Removed a redundant standalone sentence ("Ultimately this interaction creates a pro-inflammatory GI environment").
- Combined the dysbiosis definition with the sentence describing the immune response.
- Shortened the UPF risk sentence by removing "across multiple categories."
- Added an explicit definition of food insecurity (FI) at first use.
- Combined the separate sentences on UPF and FI's shared effect on nutritional deficiencies.
- Fixed a grammar issue in the closing sentence.
- Explicitly tied UPF and FI prevalence back to gastrointestinal damage.
- Removed the redundant re-definition of FI in this paragraph.
- Explicitly stated what prior research lacked: reliance on self-reported measures within a single institution, limiting generalizability.
- Detailed what this study's approach adds: publicly available, county-level indicators that capture structural conditions independent of individual patient recall.
- Expanded acronym and included the Agency for Toxic Substances and Disease Registry as owner of the SVI datasets

METHODS

- Added IRB/data-access statement.
- Specified MDC filtering was for digestive diseases and that ICD-9/ICD-10 diagnosis codes were not used.
- Added inclusion/exclusion criteria: records with unknown/missing county excluded.
- Added how the possibility of repeat admissions were handled.
- Added how missing sex in records were handled.
- Specified data acquisition method.
- Corrected the SNAP eligibility to 165% FPL (Texas-specific).
- Updated the "other federal nutrition programs" income range to 165–185% FPL to stay consistent with the corrected SNAP threshold.
- Added R version and citation (version 4.5.2; R Core Team, 2025).

- Mentioned specific R packages: ordinal for the regression model, rcompanion for Nagelkerke's pseudo R^2, MASS and brant for the proportional odds test, AER for p-values and coefficient testing.
- Added model fit statistics reported: likelihood ratio test against the null model, Nagelkerke's pseudo R^2.
- Added proportional odds assumption testing through the Brant test.
- Added pairwise correlation check conducted across all continuous predictors.
- Added a closing sentence noting p-values and odds ratios of independent variables were evaluated.

RESULTS

- Referred back to the APR-DRG severity scale defined in Methods.
- Rounded to 2 decimal places.
- Added a note that higher RPL values indicate greater social vulnerability in text.
- Added a sentence stating all predictors were entered simultaneously into a single model.
- Added model fit statistics.
- Rounded all odds ratios and p-values to 2 decimal places.
- Replaced the "% FI low threshold" odds ratio (which rounded misleadingly to 1.00) to a plain-language description of a negligible, non-significant association.
- Rounded all odds ratios and p-values to 2 decimal places.
- Removed "Despite the weak correlation"
- Explained "positive association": "meaning the odds of severe illness rose as age increased."
- Rounded all odds ratios and p-values to 2 decimal places.
- Explained "inversely associated" for Theme 1: "meaning higher socioeconomic vulnerability corresponded to lower odds of severe illness in this sample."
- Rounded all odds ratios and p-values to 2 decimal places
- Rewrote the male/female comparison sentence to avoid reporting two odds ratios that round to an identical value (1.00). Replaced the misleading rounded comparison with a plain description.
- Added a new paragraph for the proportional odds assumption test with the omnibus result ($\chi^2 = 68.93$, df = 30, $p < 0.001$) and four individually violating predictors.

DISCUSSION

- Removed repeated statistical parentheticals already reported in Results.
- Removed causal language.
- Discussed the ecological fallacy since this paragraph draws on individual-level literature to plausibly explain a county-level finding.
- Marked proposed biological mechanisms as untested by this study rather than established fact.
- Explicitly stated that the findings cannot account for the effectiveness of SNAP since individual enrollment was never measured, only county-level income eligibility.
- Clarified that the "SNAP gap" population still qualifies for other federal nutrition programs like WIC.

- Added Ratcliffe et al. (2011) alongside Geanacopoulos et al. (2025) as the citation for SNAP's effect on reducing food insecurity.
- Replaced "more severe manifestations of IBD compared to the pediatric age group" with "more than double the odds of severe illness relative to the pediatric age group."
- Marked the immunosenescence/cytokine mechanism as a proposed explanation
- Discussed the role of healthcare-utilization explanation in the null SVI findings are a hypothesis for future research rather than an established cause.
- Noted that insurance status was unavailable in this dataset to directly test this explanation.

LIMITATIONS

- Explicitly named and cited the ecological fallacy, stating that county-level food insecurity does not necessarily reflect any individual patient's actual food security status.
- Added a new paragraph disclosing that no formal missing-data model was used.
- Listed variables unavailable in this dataset that could not be adjusted for.
- Added a new paragraph reporting the multicollinearity finding and its likely effect on model stability.
- Added a possible explanation for the Brant test violations.

CONCLUSION

- Added "in our sampled population" to the severity finding to avoid overgeneralization.
- Removed causal phrasing.
- Provided a scope to null findings in this study.
- Removed redundant language about incorporating food-access screening into IBD care.

REFERENCES

- Added Robinson, W. S. (2009) entry.
- Added R Core Team (2025) entry.

Decision: Accept for publication, pending minor edits.

Review: This manuscript has improved considerably since its initial submission, and it is clear that the student has responded materially to both reviews. The statistical/methodological design is now sensible (although not without some issues), and the prose and acknowledgements of both limitations and nuances demonstrate considerable maturity and honesty. Several concrete things should be corrected, but I think the model and methodology are good enough, particularly for a junior journal.

Final revisions:

1. Please make the description of the study population consistent. The Abstract and Discussion refer to the cohort as "2,000 adults," but the dataset appears to include 221 patients aged 0-17. Please also use a more consistent term, either "adults" or "patients," or another accurate term throughout.
2. The text uses a 3.40% increase per percentage point and calculates a food insecurity odds ratio of approximately 1.89 across the observed range, while Table 2 lists the coefficient as 1.03. You should explain this inconsistency or correct it.
3. You should revise the Abstract's description of the "between thresholds" food insecurity variable. This is a county-level percentage, not a characteristic measured for individual patients. Also, these individuals are above SNAP eligibility but could still qualify for other federal nutrition programs. The current wording, which says they "do not qualify for Supplemental Nutrition Assistance Program (SNAP) or other federal nutrition programs," is therefore inconsistent with the Methods and Discussion.
4. Use consistent APR-DRG severity terminology, as the manuscript alternates among "Mild/Minor," "Major/Severe," and "Extreme/Very Severe." You should use official categories consistently throughout: Minor, Moderate, Major, and Extreme
5. Table 2 shows three sex categories with odds ratios, but a three-category factor normally requires one reference group and two estimated contrasts. Clearly identify the reference category or explain how the displayed odds ratios were calculated.
6. It is good that the manuscript reports the violation of the Brant test and identifies the affected predictors. However, avoid overexplaining that the violations for the SVI variables are caused by collinearity unless this was rigorously demonstrated through statistical tests; simply state that both issues were observed and may affect interpretation.
7. Try to use more associational rather than causal language. (Remember, correlation does not equal causation!) E.g., in the Discussion, the statement that cross-sectional findings demonstrate that dietary patterns "<u>cause</u> inflammation and immune overactivation" should be changed to wording such as "<u>are associated</u> with inflammation and immune activation."
8. The cited Narula et al. (2021) paper concerns UPF intake and IBD risk and does not appear to be the NHANES source for the reported 55% U.S. caloric-intake statistic. Please replace this with the appropriate NHANES/CDC source.
9. Some of the technical wording is off. Nagelkerke's pseudo-R2 is technically just a model-fit/pseudo-R2 measure rather than literally the "proportion of variance explained"

(although that could be a helpful heuristic), and clarify exactly which R function/package was used to fit the ordinal regression and which was used for the Brant test.

The above revisions should substantially improve the manuscript's precision without requiring a major redesign of the analysis, which I do not believe is warranted at this stage, especially given the two peer reviewer recommendations (which were both conditional acceptances with minor revisions).