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Digestive Supplement Use and Abdominal Pain Among U.S. Adults: A Survey-Weighted Analysis of NHANES 2017–2018

Susy Cedeno Arevalo[1,2*], Maria Lucia Andrews[1,3], Tanya Mateo[1,4], Branda Arismendy[1], Luisa Cruz[1,5], Andres Gomez[1], Raphaela Anderson Colares[1,6], Daniel Villareal[1,7], Daniela Godoy[1,8], Oludolapo Omoyiola[1,9], Shailza Kathuria[1], Camila Schumacher Kluge[1,10], Yasmim Helen Dias de Souza[1,10], Abisoye Ajayi[1,9], Jerry Li[1], Aline Fares[1], Beatriz Bartulic Machado[1], Natalia Soto[1,11], Hebe Castillo Molina[1,12], Alessandro Solis[1,13], Giannina Melgarejo[1], Dorcas Thairu[1], Oluwatosin Ajibola[1,9], Erica Adissy[1,14], Ahmed Salem Alsuliamani[1,15], David Rodriguez[1,16], Ana Fandinho[1,6], Federica Rossetto[1,17]

[1] Harvard T.H. Chan School of Public Health - ECE - PPCR Program, Boston, MA, USA; [2] Fundación Valle del Lili, Cali, Colombia; [3] Candel Therapeutics; [4] CEDIMAT, Santo Domingo, Dominican Republic; [5] Pontificia Universidad Católica Madre y Maestra (PUCMM), Santiago, Dominican Republic; [6] Instituto D'Or de Pesquisa e Ensino, Rio de Janeiro, Brazil; [7] Beth Israel Deaconess Medical Center, Boston, MA, USA; [8] Hospital del Trabajador, Santiago, Chile; [9] Memorial Sloan Kettering Cancer Center; [10] Faculdade São Leopoldo Mandic, Campinas, SP, Brazil; [11] Tecnológico de Monterrey, CCM, Mexico; [12] Facultad Mexicana de Medicina Universidad La Salle (FMM ULSA), Ciudad de México, México; [13] Universidad de Ciencias Médicas UCIMED, San José, Costa Rica; [14] Hospital do Coração, Brazil; [15] King Fahad Medical City, Riyadh, Saudi Arabia; [16] Abbott EPD, Bogotá, Colombia; [17] Fondazione Don Carlo Gnocchi Onlus, Italy.

Abstract

Background: *Digestive supplements are widely used in the United States, yet their association with gastrointestinal symptoms in the general population remains unclear.*

Objective: *To evaluate the association between digestive supplement use and self-reported abdominal pain among U.S. adults using nationally representative NHANES 2017–2018 data.*

Methods: *We analyzed 5,564 adults aged ≥20 years from NHANES 2017–2018. The exposure was self-reported use of supplements to improve digestion. The outcome was abdominal pain during the past 12 months. Survey-weighted logistic regression models were used to estimate crude and adjusted odds ratios (ORs), accounting for demographic, socioeconomic, behavioral, and clinical covariates. Effect modification by age was assessed through interaction testing and stratified analyses.*

Results: *The analytic sample included 5,569 adults (mean age 48.3 years; 53.1% female; mean BMI 29.8 kg/m^2). Overall, 5.7% reported supplement use for digestion. In unadjusted analyses, supplement use was significantly associated with abdominal pain (OR 1.76, 95% CI 1.18–2.64, $p = 0.009$). In the fully adjusted model, the association was attenuated and no longer statistically significant, though a trend remained (OR 1.58, 95% CI 0.96–2.60, $p = 0.068$). Anxiety (OR 2.21, 95% CI 1.77–2.76), sleep disturbance (OR 1.97, 95% CI 1.62–2.39), and prior gallbladder surgery (OR 2.42, 95% CI 1.61–3.62) were independently associated with abdominal pain. Although the overall supplement-by-age interaction was not statistically significant, stratified analyses demonstrated progressively stronger associations with advancing age, reaching statistical significance among adults aged ≥60 years.*

Conclusions: *Digestive supplement use was more strongly associated with abdominal pain among older adults, although the overall association attenuated after adjustment for demographic, psychosocial, and clinical factors. Anxiety, sleep disturbance, and prior gallbladder surgery emerged as independent correlates of abdominal pain. The cross-sectional design precludes determination of temporality; abdominal pain may lead to increased supplement use, supplement use may contribute to symptoms in some individuals, or both mechanisms may coexist. These findings highlight the importance of contextualizing digestive supplement use within broader clinical and psychosocial profiles, particularly in aging populations.*

Introduction

More than 50% of Americans report using at least one dietary supplement, reflecting the widespread use of these products in health and wellness practices (Cohen & Bass, 2019). Supplements are products that contain essential dietary ingredients such as minerals, amino acids, vitamins, and other edible substances

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like botanicals or herbs (Djaoudene et al., 2023). Since 1994, the U.S. government has regulated these products through the Dietary Supplement Health and Education Act (DSHEA), which designated the FDA (Food and Drug Administration) to oversee them as a subcategory of food (Antonio et al., 2025). It is important to note that supplements do not require pre-market approval, however, manufacturers are responsible for ensuring the safety of their products (Denham, 2021). The overall impact of this on healthcare is still under review.

Digestive supplements include a wide variety of products that include probiotics, prebiotics and synbiotics that are widely marketed for gastrointestinal health and have become increasingly used in the general population. O'Connor et al. (2021) reported that approximately 4.5% of U.S. adults and children used nonfood probiotic products, underscoring both their popularity and their growing role in health practices.

Evidence regarding the efficacy of probiotics and other digestive supplements remains inconclusive. Some systematic reviews and clinical trials suggest benefits such as modulation of the gut microbiota and improvement of gastrointestinal symptoms, including abdominal pain and bloating (Zhang et al., 2022). However, other studies report inconsistent results influenced by strain, dosage, or host characteristics. Concerns have also been raised about possible adverse effects, particularly in vulnerable populations, underscoring the heterogeneity of current findings (Rasaei et al., 2024; Dore et al., 2019). Importantly, most of this research has been conducted in clinical settings or in narrowly defined patient populations, such as individuals with irritable bowel syndrome (Zhang et al., 2022) or inflammatory bowel disease (Dore et al., 2019).

Although a growing number of Americans use digestive supplements, there is still a significant knowledge gap regarding their relationship with gastrointestinal symptoms in the general population; therefore, nationally representative data are needed to better understand patterns of use and their potential public health implications. Furthermore, it remains unclear how these associations might differ among key demographic and health subgroups, such as those defined by age, sex, obesity, or diabetes status, highlighting a need for more detailed and nuanced research. To answer this gap, we used data provided by The National Health and Nutrition Examination Surveys (NHANES) 2017–2018 cycle, a large, population-based survey designed to represent the noninstitutionalized U.S. population. This cycle was selected because it was the last completed before the COVID-19 pandemic, which substantially altered supplement consumption patterns (Fulford, 2024; Lin, 2024).

The aim of this study was to evaluate the association between digestive supplement use and self-reported abdominal pain in the past 12 months among U.S. adults participating in the NHANES 2017–2018 survey, leveraging nationally representative data and adjusting for key sociodemographic and clinical covariates.

Materials and Methods

Study design and data source

This study used data from the 2017–2018 cycle of the National Health and Nutrition Examination Survey (NHANES), a nationally representative, cross-sectional survey conducted by the National Center for Health Statistics (NCHS). The NHANES survey is conducted in two-year cycles and uses a complex, multistage probability sampling designed with stratification, clustering, and oversampling of specific subpopulations to ensure representativeness of the U.S. civilian, noninstitutionalized population. The data are collected using standardized protocols across multiple domains, including physical examination, questionnaires, laboratory testing, and dietary assessments. Although NHANES is cross-sectional and cannot establish temporal or causal relationships, its comprehensive design and sampling framework allow for robust, hypothesis-generating analyses with high external validity. All analyses incorporated the NHANES sampling design elements, sample weights, strata, and primary sampling units, to produce nationally weighted estimates.

Study population

The analytic sample included adults aged 20 years and older with complete data for the outcome and exposure variables. This approach is consistent with prior NHANES-based studies that limit analyses to adults aged 20 years and older when using similar questionnaire items. In addition, health behaviors and supplement use patterns differ substantially between adults and younger populations, supporting this restriction (Juul et al., 2022; Jia et al., 2024). The inclusion criteria were (1) participation in the NHANES 2017–2018 cycle, (2) age $\geq$20 years; and (3) availability of complete data for the exposure, outcome, and covariates. The exclusion criteria were (1) participants younger than 20 years; (2) missing information on abdominal pain (mcq520), supplement use (dsd128z), or any covariate. Of 9,254 adults aged 20 years or older in the 2017–2018 cycle, 3,690 were excluded due to missing data for the exposure, outcome, or covariates. After applying these criteria,

the final analytic sample comprised 5,564 individuals.

Variables

The exposure variable was self-reported supplement use for digestion (dsd128z; "Took supplements to improve digestion," yes/no). The outcome was self-reported abdominal pain during the past 12 months (mcq520; "During the past 12 months, have you had pain or discomfort in your abdomen?"). Both variables were coded as binary (yes = 1, no = 0).

Covariates

The variables selected in the present study were justified by literature relevance as potential confounders of the association between supplement use and abdominal pain, aiming to improve validity of the estimated association. Demographics and clinical characteristics, such as age, sex, BMI (body mass index), diabetes and income status measured by income-to-poverty ratio (PIR) were included in the analysis. Additionally, we added education level, gallbladder surgery status, smoking status, alcohol intake, anxiety and sleep disturbance (Appendix A). This expanded confounder set aimed to strengthen model validity and address potential residual confounding within the constraints of available NHANES data.

Effect modifiers

Based on prior literature, effect modification was evaluated for age, categorized into three groups (20–39, 40–59, 60–100 years). Although potential modifiers such as sex, obesity, and diabetes were initially considered, the age-stratified analysis was prioritized given its greater clinical plausibility and statistical relevance in exploratory models. Obesity and diabetes were retained as confounders in adjusted analyses but not as effect modifiers, as no significant interactions were observed.

Statistical analysis

Descriptive statistics were used to summarize population characteristics, with means and standard deviations reported for continuous variables and proportions for categorical variables. Comparisons between supplement users and non-users were performed using survey-weighted t-tests for continuous variables and design-based χ^2 tests for categorical variables. For continuous variables, additional nonparametric sensitivity analyses were conducted to assess the robustness of results in relation to the normality assumption, with specific tests applied to evaluate distributional characteristics.

Logistic regression models with survey weights were fitted to estimate the association between supplement use and abdominal pain. Both crude and adjusted models were developed, with the latter including age, sex, BMI, and diabetes as covariates. Additional variables, education level, income-to-poverty ratio (PIR), smoking status, alcohol intake, anxiety, sleep disturbance, and history of gallbladder surgery, were evaluated individually as potential confounders and retained in the final model if their inclusion meaningfully altered the main effect estimate.

Effect modification was assessed by including interaction terms (supplement $\times$ modifier) and by performing stratified analyses when significant; certain covariates were defined a priori as potential effect modifiers. In particular, age was stratified into three predefined groups (20–39, 40–59, and 60–100 years) for interaction and stratified analyses, based on biological plausibility and age-related variation in comorbidities and supplement use. When significant interactions were identified, stratified models were examined to estimate age-specific odds ratios.

Model diagnostics included assessment of linearity-in-the-logit using the Box–Tidwell test. Evaluation of multicollinearity among covariates was assessed using variance inflation factors (VIFs), with no problematic collinearity identified (all VIFs < 2). Model fit was further evaluated using Wald χ^2 tests. Pseudo-R^2 values were reported as part of model outputs but were interpreted descriptively, acknowledging that low values are expected in survey-weighted analyses and reflect the multifactorial nature of the outcome rather than poor model fit. Statistical significance was set at $p < 0.05$. All analyses incorporated the NHANES complex sampling design—strata, primary sampling units, and sampling weights—using the svyset command in STATA 19.5 (StataCorp, College Station, TX), and listwise deletion was applied to missing data.

Results

Study population characteristics

he analytic sample included n = 5,569 adults, representing a weighted U.S. population of approximately 238 million individuals. The mean age was 48.3 (SE 0.53) years and 51.5% were female. The weighted mean BMI was 29.9 kg/m. (SD 0.26), and 42.6% of participants were classified as obese (BMI $\geq$30). Diabetes was reported by 11.85% of participants (Table 1). Overall, 5.7% reported using supplements for digestion.

Variable	Total weighted (%)	No supplement (%) or mean (95% CI)	Supplement (%) or mean (95% CI)	P-Value (survey-adjusted)
Total	13.7 / 238.7 million	94.3% (92.0 - 95.0)	5.7% (4.4 – 7.3)	-
Age, years	48.3 (47.1 - 49.4)	48.1 (47.0 - 49.2)	51 (47.0 - 55.0)	0.04
Female sex	5.7% (4.44 - 7.37)	4.7% (3.36 - 6.54)	6.6% (4.58 - 9.66)	0.17
High education	88.6% (86.83 - 90.29)	88.34% (86.44 - 90.0)	94.18% (91.68 - 95.96)	<0.001
Income-to-poverty ratio	3.0 (2.93 - 3.19)	3.0 (2.9 - 3.15)	3.6 (3.27 - 3.94)	0.02
High income (PIR>4)	44.68% (40.45 - 48.98)	44.22% (39.98 - 48.54)	52.19% (40.49 - 63.66)	0.17
BMI, kg/m²	29.8 (29.27 - 30.39)	29.8 (29.3 - 30.3)	29.7 (27.4 - 32.1)	0.44
Obesity (BMI≥30)	42.6% (39.05 - 46.37)	57.0% (53.94 - 60.16)	38.5% (25.31 - 53.78)	0.47
Diabetes (self-reported)	11.85% (10.74 – 13.06)	12.4% (10.9 - 13.28)	8.6% (5.31-13.9)	0.16
Gallbladder surgery	12.13% (10.19 - 14.39)	11.64% (9.72 - 13.89)	20.23% (12.65 - 30.76)	0.03
Ever smoked (≥100 cigarettes)	42.23% (38.91 - 45.63)	42.6% (39.57 - 45.69)	36.21% (26.8 - 46.8)	0.13
Current smoker	41.27% (37.56 - 45.09)	42.5% (38.63 - 46.46)	17.55% (10.12 - 28.69)	<0.001
Alcohol use >3 times/month	43.31% (40.37 - 46.31)	42.69% (40.11 - 45.3)	53.55% (32.66 - 73.26)	0.29
Frequent anxiety (daily or weekly)	33.39% (31.7 - 35.12)	32.76% (31.06 - 34.51)	43.65% (33.7 - 54.14)	0.04
Frequent sleep problems	16.06% (14.4 - 17.88)	15.77% (14.15 - 17.5)	20.74% (16.18 - 26.18)	0.02

Table 1: *Weighted characteristics of the study population by supplement use (NHANES 2017–2018).*

Covariate	OR	95% CI	P-Value
Crude	**1.76**	**1.18 - 2.64**	**0.01**
Supplement use (Yes)	1.58	0.96 – 2.60	0.06
Age (Continuous)	1.00	0.99 - 1.01	0.90
Female (Yes)	1.07	0.80 - 1.42	0.64
BMI (continuous)	0.99	0.98 - 1.01	0.36
Diabetes (Yes)	1.27	0.90 - 1.80	0.15
High Education	0.84	0.62 - 1.12	0.21
High income	0.82	0.63 - 1.07	0.13
Frequent anxiety	2.21	1.77 - 2.76	<0.00
Frequent sleep problems	1.97	1.62 - 2.39	<0.00

Odds ratios (OR) represent the likelihood of abdominal pain compared with the reference group.

Table 2: *Survey-weighted models multivariable model (5,141 Observations) (NCHS, 2020).*

Variable	OR	95% CI	P-Value
Supplement x Age group 20-39 years	1.10	0.54 - 2.24	0.77
Supplement x Age group 40-59 years	1.41	0.63 - 3.18	0.37
Supplement x Age group 60+ years	2.92	1.48 - 5.77	<0.00
Joint test (age groups)	-	-	F (2,14) = 2.43, p=0.124

Odds ratios (ORs) greater than 1 indicate higher odds of reporting abdominal pain compared with the reference group (non-users).

Table 3: *Interaction model of supplement use and abdominal pain by age group (Weighted NHANES 2017-2018).*

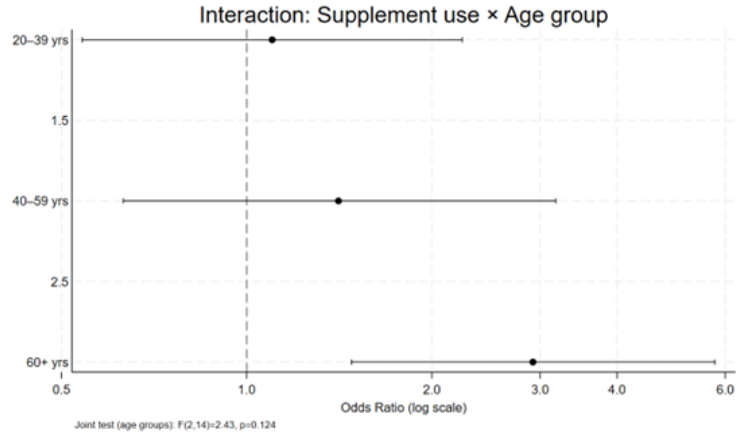

Figure 1: *Modification of effect by age: use of supplements "for digestion" and abdominal pain (NHANES 2017–2018). Forest plot of stratified odds ratios (OR) with 95% CI for the association between supplement use and abdominal pain in the 20–39, 40–59, and ≥60 age groups.*

Distributional assumptions for age and BMI were evaluated using histograms, Q–Q plots, and skewness–kurtosis tests, which indicated non-normality; however, homogeneity of variances was confirmed. Therefore, group comparisons were conducted using Student's t-tests as the primary analysis, with Wilcoxon rank-sum tests performed as sensitivity analyses. Compared with non-users, supplement users were slightly older (53.6 vs 51.4 years, p = 0.04). Mean BMI did not differ significantly by supplement use (30.3 vs 29.8 kg/m², p = 0.299). Supplement use was more common among women (6.7% vs 4.7%, p = 0.17, survey-adjusted). Prevalence of obesity and diabetes was similar between groups ($p > 0.10$).

In weighted analyses, supplement users tended to have a higher family income-to-poverty ratio (mean 3.61 vs 3.03, p = 0.043), were more likely to report frequent anxiety (7.5% vs 4.9%, p = 0.036), and more likely to experience sleep problems (7.6% vs 5.5%, p = 0.024). No significant differences were observed for smoking or alcohol use.

Crude and adjusted models

In the unadjusted (survey-weighted) model, supplement use was associated with higher odds of abdominal pain (OR 1.76, 95% CI 1.18–2.64, p = 0.009) (Table 2). After adjusting individually for potential confounders such as age, sex, BMI, diabetes, education, income, smoking, alcohol use, anxiety, sleep problems, and gallbladder surgery, the odds ratio for supplement use remained between 1.62 and 1.94, suggesting relative stability of the association.

In the fully adjusted weighted model, including all significant and confounding variables (age, sex, BMI, diabetes, education, income, anxiety, sleep disturbances, and gallbladder surgery), the association between supplement use and abdominal pain was attenuated and no longer statistically significant (OR 1.58, 95% CI 0.96–2.60, p = 0.068). Anxiety (OR 2.21, 95% CI 1.77–2.76, $p < 0.001$), sleep problems (OR 1.97, 95% CI 1.62–2.39, $p < 0.001$), and prior gallbladder surgery (OR 2.42, 95% CI 1.61–3.62, $p < 0.001$) remained independently associated with abdominal pain (Table 2). The overall model was statistically significant (survey-adjusted Wald F(10,6) = 18.59, p = 0.001), indicating good model fit under the complex sampling design.

Linearity checks

We assessed the linearity-in-the-logit assumption for the continuous predictors using the Box–Tidwell method. The interaction terms age·ln(age) (p = 0.58) and BMI·ln(BMI) (p = 0.77) were not statistically significant, indicating that the assumption of linearity in the logit was satisfied for both variables. Consequently, age and BMI were modeled as continuous predictors. However, the interaction term for the family income-to-poverty ratio (PIR·ln[PIR]) was statistically significant (p = 0.004), suggesting a violation of linearity. Therefore, PIR was categorized into income groups (≤4 vs >4) for subsequent analyses.

Effect Modification

Age was evaluated as a potential effect modifier given its biological plausibility and the likelihood that comorbidities and supplement use behaviors vary across life stages. The survey-adjusted interaction between supplement use and age group was not statistically significant overall (joint test

F(2,14) = 2.43, p = 0.12); however, stratified models revealed a progressive increase in the strength of association with advancing age. Among adults aged 20–39 years, the odds ratio for supplement use was 1.10 (95% CI 0.54–2.24, p = 0.78); in those aged 40–59 years, 1.41 (95% CI 0.63–3.18, p = 0.38); and in those aged $\geq$60 years, 2.92 (95% CI 1.48–5.77, p = 0.004) (Table 3 and Figure 1). No significant interactions were observed for sex, obesity, or diabetes in prior models (all $p > 0.05$), and therefore only age was retained for stratified analyses.

Discussion

In this nationally representative sample of U.S. adults from the NHANES 2017–2018 survey, supplement use for digestion was associated with higher odds of abdominal pain in the past 12 months, even after adjusting for multiple demographic, behavioral, and clinical factors, including age, sex, BMI, diabetes, education, income, smoking, alcohol intake, anxiety, sleep disturbance, and gallbladder surgery. These findings suggest that individuals reporting abdominal pain may be more likely to use digestive supplements, reflecting an underlying pattern of self-management among those with gastrointestinal discomfort rather than a causal preventive effect.

Age modified this effect, with progressively stronger relationships observed among middle-aged and older adults. Although the survey-adjusted interaction between supplement use and age group did not reach statistical significance overall, stratified models showed a clear trend of increasing odds ratios with advancing age. This pattern may reflect underlying gastrointestinal conditions more common with older age, such as diverticulosis, functional bowel disorders, side effects from chronic medications and post-surgical procedures. These findings suggest that supplements to improve digestion may be associated with prior gastrointestinal complaints. Also, younger adults may use supplements less consistently or for general wellness, explaining the lack of association in this group.

Female sex and diabetes were also associated with higher odds of abdominal pain, consistent with prior studies. Women tend to report gastrointestinal symptoms more frequently (Fan et al., 2024) or chronic pain in general (Umeda & Kim, 2019). Biological differences between female and male functional gastrointestinal disorders have been suggested (Narayanan et al., 2021), including dyspepsia and irritable bowel syndrome, where symptoms may be more severe in women. Diabetes patients have increased gastrointestinal symptoms and dysmotility, impacting their overall health (Marathe et al., 2024). Abdominal pain in diabetic patients can be explained by a combination of microvascular changes and neuropathic damage, both of which are well-established complications of chronic hyperglycemia. This physiopathology is also seen in the setting of obesity, which is often associated with diabetes. Current standard of care treatments include the use of dietary supplements, which support our findings on the association between diabetes and abdominal pain.

This study benefits from the use of NHANES, a large, nationally representative dataset with standardized data collection, enhancing generalizability. The application of survey-adjusted models provided unbiased estimates reflecting the U.S. adult population. Moreover, by systematically assessing multiple potential confounders one at a time before inclusion in the final multivariable model, we minimized residual confounding and improved the robustness of our adjusted estimates.

The large sample size allowed for subgroup analyses with sufficient power. However, its cross-sectional design, reliance on self-reports and lack of supplemental detail may limit causal inference and generalizability. Reverse causation is likely: individuals experiencing abdominal discomfort or chronic gastrointestinal symptoms may be more inclined to initiate supplement use, rather than supplements being a causal factor in symptom onset. Furthermore, the extended recall window (12 months) for pain increases the risk of recall bias and measurement error. This definition reflects a general association with non-specific gastrointestinal symptoms rather than a precise clinical diagnosis. Similarly, the exposure variable ("took supplements to improve digestion") lacks granularity regarding supplement type, dosage, motivation, and indication, representing a diverse group of behaviors rather than a unified exposure. Also, our analysis was restricted to complete cases; while this is a statistically acceptable approach, the resulting loss of sample size could introduce bias and reduce the precision and representativeness of estimates.

Future research should aim to replicate these findings using longitudinal designs that can establish temporality and minimize reverse causation. Incorporating more detailed information on supplement type, dosage, and motivation, along with clinical verification of gastrointestinal diagnoses, will be essential to clarify causality and mechanisms.

Public health implications

The relatively high use of digestive supplements, particularly the stronger associations observed among older adults, has important public health

implications. Older individuals are more likely to have multiple comorbidities, polypharmacy exposure, and age-related changes in gastrointestinal physiology, which may increase both supplement use and vulnerability to adverse effects or interactions. Given the limited regulatory oversight and the lack of detailed clinical guidance regarding digestive supplement efficacy and safety in the general population, these findings highlight the need for improved clinician-patient communication about supplement use, especially among older adults. Routine screening for supplement use in clinical encounters, clearer labeling standards, and better population-based evidence on effectiveness and safety may help reduce potential harms and support more informed decision-making.

Conclusion

In summary, this study demonstrates that the use of dietary supplements to support digestion is associated with higher odds of abdominal pain among middle-aged and older U.S. adults. Our findings reflect an association between supplements and abdominal pain, however, the temporal sequence of this association, whether dietary supplement use precedes the onset of abdominal pain, or abdominal pain leads to increased dietary supplement intake, needs to be further investigated in prospective clinical trials. These findings underscore the importance of evaluating supplement use in patients presenting with gastrointestinal complaints and highlight the need for longitudinal studies to disentangle the directionality and mechanisms underlying this association.

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Conflicts of Interest

The authors declare no conflict of interest.

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