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Patterns of Comorbidity Between Chronic Pain and Chronic Diseases in US Adults: A Cross-Sectional Analysis of NHANES Data

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Background: With the global population ageing rapidly, the combined health burden of chronic pain and chronic diseases is increasingly evident. Despite this, significant gaps remain in understanding the interrelationship between these factors.

Objective: This study aimed to examine the associations between chronic pain and a range of chronic diseases in a nationally representative sample of US adults.

Study Design: A cross-sectional analysis was performed using data from the National Health and Nutrition Examination Survey (NHANES).

Methods: Data from four NHANES cycles (1999–2004, 2009–2010) were analyzed, including 7,135 adults aged 20 years and older. Logistic regression models were used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for the association between chronic pain and each chronic disease, adjusting for sociodemographic, lifestyle, medication use, and anthropometric factors.

Results: A significant comorbidity risk was identified between chronic pain and multiple chronic diseases, with the strongest associations observed for arthritis (OR = 3.07, 95% CI: 2.71–3.48), renal failure (OR = 1.85, 95% CI: 1.36–2.51), liver disease (OR = 1.77, 95% CI: 1.37–2.29), and congestive heart failure (OR = 1.72, 95% CI: 1.24–2.40). Additionally, smoking (OR = 1.83, 95% CI: 1.66–2.02), prescription medication use (OR = 2.33, 95% CI: 2.10–2.58), and widowhood (OR = 2.13, 95% CI: 1.72–2.65) were also significant risk factors for chronic pain. Subgroup analyses of chronic conditions comorbid with chronic pain further explored the influence of specific factors.

Conclusion: Chronic pain, as a comorbid factor, should be integrated into the management of chronic diseases. Clinical practice should prioritize synergistic prevention strategies, such as smoking cessation interventions, to reduce both pain and comorbidity risks. To better understand the causal relationships between chronic pain and chronic diseases, future studies should focus on longitudinal designs and include objective pain measures, such as biomarkers.

Keywords: chronic pain, chronic disease, comorbidity, NHANES, epidemiology

Introduction

Chronic pain is clinically defined as persistent pain extending beyond expected tissue healing, typically ≥3 months in duration.[1] Recognized as a distinct clinical entity—not merely a symptom—it is codified within established diagnostic classifications.[2] In the United States, 50 million adults experience chronic pain, resulting in significant healthcare

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expenditures and lost productivity.[3,4] This high prevalence and substantial societal burden underscore the critical importance of investigating the correlates and outcomes of chronic pain specifically within the US population.

Critically, chronic pain rarely manifests in isolation. It consistently presents with major psychological comorbidities, including anxiety disorders, major depressive episodes, and chronic sleep disturbances.[5] Neurobehavioral sequelae—notably cognitive impairment and personality alterations—further contribute to functional decline.[6] Collectively, these manifestations elevate risks of premature mortality, including suicidality.[7]

Beyond psychological sequelae, chronic pain demonstrates strong syndemic relationships with physical comorbidities.[8] Robust epidemiological evidence associates it with arthritis, cardiovascular disease, and diabetes mellitus, particularly in geriatric populations.[9] This clinically significant multimorbidity correlates with reduced quality of life and elevated all-cause mortality.[9] Despite this substantial evidence, current comorbidity research remains siloed, predominantly examining isolated somatic conditions or singular mental health disorders.[10–12] A critical knowledge gap persists regarding integrated analyses of pain-disease interactions.

Amidst rapid global population aging, the synergistic burden of chronic pain and comorbid disease necessitates urgent scholarly attention. Addressing this requires systematic investigation of mechanistic pathways and population-level disease interactions. The US National Health and Nutrition Examination Survey (NHANES) is a nationally representative, methodologically rigorous database, and this study utilized multistage statistical modeling to quantify patterns of comorbidity between chronic pain and prevalent somatic diseases (coronary artery disease, diabetes mellitus, and hypertension) and to identify demographic and clinical risk factors for multimorbidity coexistence. Finally, to further explore the relationship between chronic pain and various chronic diseases (such as arthritis, diabetes, cardiovascular diseases, etc.), this study conducted subgroup analyses. By stratifying the sample according to variables such as age, sex, race, educational level, and body mass index (BMI), we aimed to reveal how these factors modulate the association between chronic pain and comorbid conditions.

Methods

Study Population

This study utilized four NHANES cycles (1999–2004, 2009–2010) with comprehensive data on chronic pain, hypertension, diabetes, and arthritis. Conducted by CDC's National Center for Health Statistics (NCHS), NHANES assesses health and nutritional status in noninstitutionalized US residents.[13] Data collection encompassed structured interviews, telephone follow-ups, mobile examination center screenings, and laboratory analyses.[14] All protocols received NCHS Research Ethics Review Board approval with participant informed consent. Data are publicly accessible at https://www.cdc.gov/nchs/nhanes/.[15]

Definition of Chronic Pain

While subtyping chronic pain could yield more granular insights, such an approach was precluded in this study due to inconsistencies in chronic pain measurements across different cycles of the NHANES database. Consequently, our analysis was based on chronic pain data from four specific survey cycles: 1999–2000, 2001–2002, 2003–2004, and 2009–2010. Chronic pain was defined as persistent or recurrent pain lasting more than three months. Pain status was determined using two items from the NHANES Miscellaneous Pain Questionnaire. The first, MPQ110, asked, "How long have you experienced this pain?" A response of three months or longer was classified as chronic pain, while a response of less than three months indicated non-chronic pain. The second, MPQ100, asked, "In the past month, have you had problems with pain lasting more than 24 hours?" An affirmative response also classified the participant as having chronic pain.[16] Participants with missing responses, "don't know" answers, or incomplete data for either item were excluded from the analysis.

Definition of Chronic Diseases

This study focuses on examining the comorbid associations between chronic pain and chronic diseases. Within the survey cycles that contained complete chronic pain data, we extracted information on chronic diseases as comprehensively as

possible. Ultimately, a total of 13 chronic conditions were included for analysis: hypertension, diabetes, asthma, congestive heart failure, coronary heart disease, arthritis, stroke, emphysema, chronic bronchitis, renal failure, liver disease, cancer, and angina. Several other common chronic conditions (such as Alzheimer's disease, epilepsy, depression, and insomnia) were excluded from the study due to incomplete data or insufficient sample sizes across the four selected survey cycles. The definitions of the chronic conditions are as follows. Hypertension was defined as an average systolic blood pressure of ≥140 mmHg or diastolic blood pressure of ≥90 mmHg, based on four measurements. Readings below these thresholds were classified as non-hypertensive.[17] Diabetes was assessed using item DIQ010, which asked, "Did your doctor tell you that you have diabetes?" A "yes" response indicated diabetes, while a "no" response indicated non-diabetes. Responses such as "borderline," "refused," or "don't know" were excluded. Asthma, congestive heart failure, coronary heart disease, arthritis, stroke, emphysema, chronic bronchitis, renal failure, liver disease, cancer, and angina were identified through self-reported physician diagnoses based on the question, "Have you been told you have chronic diseases?" A positive response indicated the presence of disease; a negative response indicated its absence. Participants with missing or uncertain responses were excluded.

Covariate

This study incorporated multiple covariates across three domains: sociodemographic (age, gender, race/ethnicity, education, income and marital status), lifestyle (smoking status and activity patterns), anthropometric (BMI) factors and prescription medication use. Race/ethnicity classifications included non-Hispanic White, non-Hispanic Black, Mexican American, other Hispanic, and other racial groups. Educational attainment was stratified into: <9 years, 9–12 years, high school diploma, college degree, and postgraduate education. Income levels were determined by poverty-to-income ratio (PIR): low (<1), moderate (1–3), and high (>3). Marital status was classified into six states: married, widowed, divorced, separated, never married, and living with partner. Activity patterns were categorized into three types: sedentary, moderate exercise, and vigorous exercise. BMI categories followed standard classifications: underweight (<18.5), normal weight (18.5–24.9), overweight (25–29.9), and obese (≥30). Smoking status differentiated never-smokers (<100 lifetime cigarettes) from ever-smokers (≥100 cigarettes).[18,19]

Statistical Analysis

Statistical analysis was conducted using R version 4.4.2, incorporating NHANES–recommended weighting and stratification. Continuous variables are presented as mean ± SD and categorical variables as frequencies (%). Group comparisons employed t-tests for continuous variables and chi-square test for categorical variables. We evaluated chronic disease-chronic pain associations using logistic regression in three models: unadjusted (Model I), adjusted for demographics (gender/age/race; Model II), and fully adjusted (Model III). We identified chronic pain risk factors through additional logistic regression. Finally, we performed subgroup analyses for those chronic diseases that showed a significant association with chronic pain.

Results

Participants

This study analyzed data from four NHANES cycles (1999–2004, 2009–2010), initially comprising 47086 participants. Since the chronic pain survey in the database targeted only individuals aged 20 years or older, we excluded 25536 individuals aged <20 years (NHANES pain survey threshold), followed by 1,112 with missing chronic pain data, 3,495 with incomplete covariates, and 9,808 with invalid/missing data. The final analytical sample included 7,135 participants (2543 with chronic pain; 4592 without chronic pain). Figure 1 details the complete selection process.

Baseline Characteristics

Table 1 presents the baseline characteristics of the 7,35 study participants, comprising 2543 (35.6%) with chronic pain and 4592 (64.4%) without chronic pain. The cohort had a mean age of 45.43 ± 15.85 years, with near-equal gender distribution (46.35% male, 53.65% female). Non-Hispanic White participants represented the largest racial group

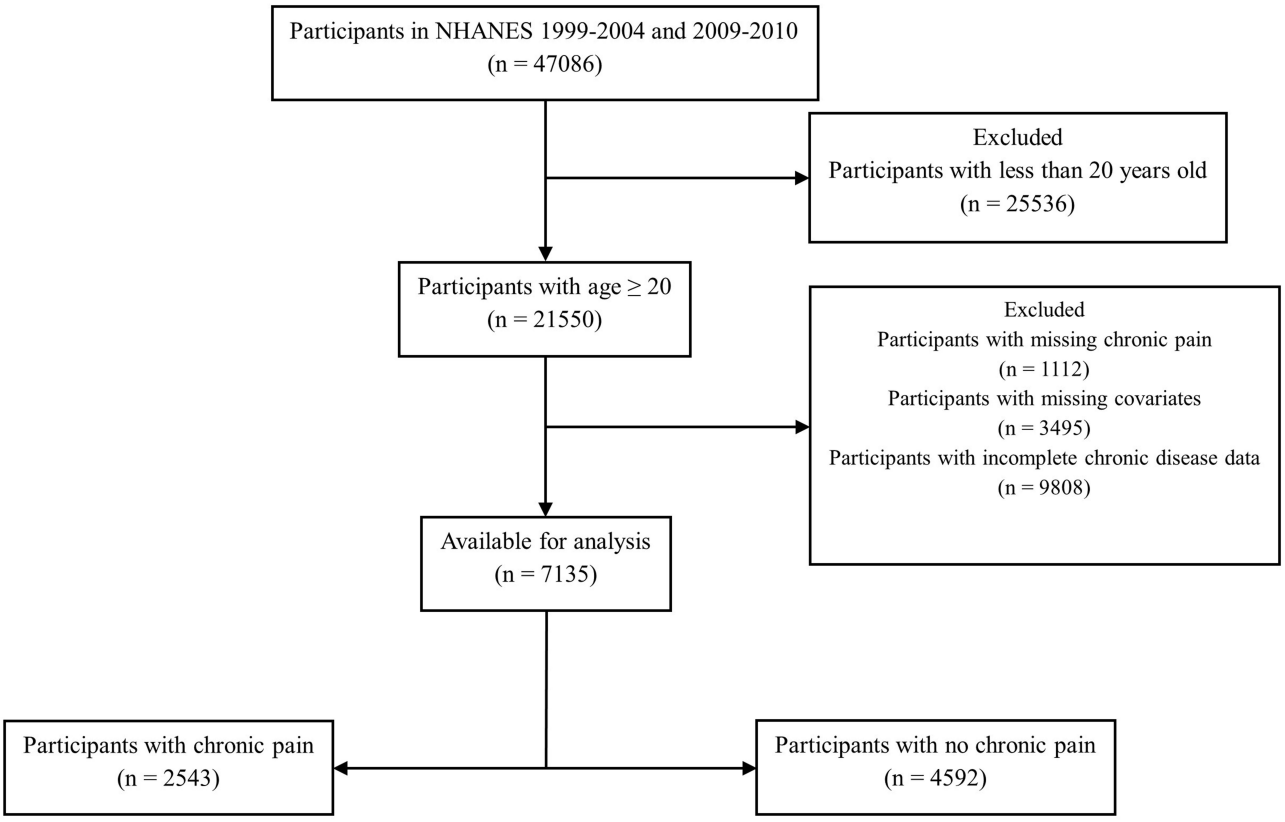

Figure 1 Participant inclusion exclusion flowchart.

(50.86%). Significant between-group differences (P<0.05) were observed for gender, age, race, education level, household poverty-to-income ratios, BMI, sedentary, prescription medication use marital status and smoking status, while vigorous exercise and moderate exercise showed no significant variation (P>0.05). Complete demographic details are provided in Table 1.

Table 1 Characteristics of NHANES Participants, 1999–2004 and 2009–2010

Variables	Total (n = 7135)	Chronic Pain		*P*-value
		Yes (n = 2543)	No (n = 4592)	
Age, Mean ± SD	45.43 ± 15.50	49.47 ± 15.85	43.20 ± 14.84	<0.001
Gender, n (%)				<0.001
Male	3307 (46.35)	1099 (43.22)	2208 (48.08)	
Female	3828 (53.65)	1444 (56.78)	2384 (51.92)	
Race, n (%)				<0.001
Mexican American	1296 (18.16)	377 (14.83)	919 (20.01)	
Other Hispanic	562 (7.88)	127 (4.99)	435 (9.47)	
Non-Hispanic White	3629 (50.86)	1503 (59.10)	2126 (46.30)	
Non-Hispanic Black	1311 (18.37)	443 (17.42)	868 (18.90)	
Other Race	337 (4.72)	93 (3.66)	244 (5.31)	

(*Continued*)

Table 1 (Continued).

Variables	Total (n = 7135)	Chronic Pain		*P*-value
		Yes (n = 2543)	No (n = 4592)	
PIR, n (%)				0.015
<1	1604 (22.48)	608 (23.91)	996 (21.69)	
1–3	2891 (40.52)	1046 (41.13)	1845 (40.18)	
>3	2640 (37.00)	889 (34.96)	1751 (38.13)	
Education, n (%)				<0.001
Less Than 9th Grade	776 (10.88)	288 (11.33)	488 (10.63)	
9–11th Grade	1141 (15.99)	441 (17.34)	700 (15.24)	
High School Grad	1709 (23.95)	663 (26.07)	1046 (22.78)	
Some College	2076 (29.10)	772 (30.36)	1304 (28.40)	
College Graduate or above	1433 (20.08)	379 (14.90)	1054 (22.95)	
BMI, n (%)				0.002
<18.5	120 (1.68)	44 (1.73)	76 (1.66)	
18.5–24.9	1920 (26.91)	620 (24.38)	1300 (28.31)	
≥30	2721 (38.14)	1029 (40.46)	1692 (36.85)	
25.0–29.9	2374 (33.27)	850 (33.43)	1524 (33.19)	
Vigorous exercise, n (%)				0.449
Yes	1728 (24.22)	629 (24.73)	1099 (23.93)	
No	5407 (75.78)	1914 (75.27)	3493 (76.07)	
Moderate exercise, n (%)				0.457
Yes	3039 (42.59)	1098 (43.18)	1941 (42.27)	
No	4096 (57.41)	1445 (56.82)	2651 (57.73)	
Sedentary, n (%)				0.009
Yes	6144 (86.11)	2153 (84.66)	3991 (86.91)	
No	991 (13.89)	390 (15.34)	601 (13.09)	
Smoke, n (%)				<0.001
Yes	3505 (49.12)	1495 (58.79)	2010 (43.77)	
No	3630 (50.88)	1048 (41.21)	2582 (56.23)	
Prescription Medication Use, n (%)				<0.001
Yes	4148 (58.14)	1802 (70.86)	2346 (51.09)	
No	2987 (41.86)	741 (29.14)	2246 (48.91)	
Marital Status, n (%)				<0.001
Married	3805 (53.33)	1380 (54.27)	2425 (52.81)	
Widowed	361 (5.06)	198 (7.79)	163 (3.55)	
Divorced	819 (11.48)	345 (13.57)	474 (10.32)	
Separated	278 (3.90)	97 (3.81)	181 (3.94)	
Never married	1283 (17.98)	321 (12.62)	962 (20.95)	
Living with partner	589 (8.26)	202 (7.94)	387 (8.43)	

Note: Data are shown as mean ± SD and n (%).
Abbreviations: SD, standard deviation; PIR, Poverty income ratio; BMI, body mass index; NHANES, National Health and Nutrition Examination Survey.

Co-morbid Features of Chronic Pain and Chronic Diseases

Table 2 presents chronic disease comorbidities among participants with chronic pain. All between-group differences reached statistical significance (P<0.05). Among the 2543 chronic pain patients, prevalent comorbidities included arthritis (47.42%), hypertension (20.21%), asthma (17.81%), diabetes (12.98%), and cancer (11.25%). Complete comorbidity data are presented in Table 2.

Table 2 Co-Morbid Characteristics of Chronic Pain and Chronic Diseases

Variables	Total (n = 7135)	Chronic Pain		*P*-value
		Yes (n = 2543)	No (n = 4592)	
Hypertension, n (%)				<0.001
Yes	1173 (16.44)	514 (20.21)	659 (14.35)	
No	5962 (83.56)	2029 (79.79)	3933 (85.65)	
Asthma, n (%)				<0.001
Yes	1055 (14.79)	453 (17.81)	602 (13.11)	
No	6080 (85.21)	2090 (82.19)	3990 (86.89)	
Arthritis, n (%)				<0.001
Yes	2008 (28.14)	1206 (47.42)	802 (17.47)	
No	5127 (71.86)	1337 (52.58)	3790 (82.53)	
Congestive heart failure, n (%)				<0.001
Yes	173 (2.42)	111 (4.36)	62 (1.35)	
No	6962 (97.58)	2432 (95.64)	4530 (98.65)	
Coronary heart disease, n (%)				<0.001
Yes	261 (3.66)	152 (5.98)	109 (2.37)	
No	6874 (96.34)	2391 (94.02)	4483 (97.63)	
Angina, n (%)				<0.001
Yes	227 (3.18)	152 (5.98)	75 (1.63)	
No	6908 (96.82)	2391 (94.02)	4517 (98.37)	
Stroke, n (%)				<0.001
Yes	210 (2.94)	108 (4.25)	102 (2.22)	
No	6925 (97.06)	2435 (95.75)	4490 (97.78)	
Emphysema, n (%)				<0.001
Yes	144 (2.02)	91 (3.58)	53 (1.15)	
No	6991 (97.98)	2452 (96.42)	4539 (98.85)	
Chronic bronchitis, n (%)				<0.001
Yes	492 (6.90)	274 (10.77)	218 (4.75)	
No	6643 (93.10)	2269 (89.23)	4374 (95.25)	
Liver disease, n (%)				<0.001
Yes	270 (3.78)	147 (5.78)	123 (2.68)	
No	6865 (96.22)	2396 (94.22)	4469 (97.32)	
Cancer, n (%)				<0.001
Yes	573 (8.03)	286 (11.25)	287 (6.25)	
No	6562 (91.97)	2257 (88.75)	4305 (93.75)	
Diabetes, n (%)				<0.001
Yes	731 (10.25)	330 (12.98)	401 (8.73)	
No	6404 (89.75)	2213 (87.02)	4191 (91.27)	
Renal failure, n (%)				<0.001
Yes	190 (2.66)	109 (4.29)	81 (1.76)	
No	6945 (97.34)	2434 (95.71)	4511 (98.24)	

Analysis of the Association Between Chronic Pain and Common Chronic Diseases

Our unadjusted analysis (Model I) revealed significant associations between chronic pain and multiple chronic diseases, particularly arthritis (OR = 4.26, 95% CI: 3.82–4.75), renal failure (OR = 2.49, 95% CI: 1.86–3.43), liver disease (OR = 2.23, 95% CI: 1.75–2.85) and angina (OR = 3.83, 95% CI: 2.89–5.07). These associations remained significant in Model II after adjusting for sex, age, and race, though with attenuated effect sizes. The fully adjusted Model III (incorporating all covariates) maintained significant associations for most conditions, except hypertension, stroke, cancer and diabetes, which showed non-significant results (95% CI including 1). Complete regression results are presented in Table 3.

Table 3 Association Analysis Between Chronic Pain and Common Chronic Diseases

Variables	OR (95% CI)		
	Model I	Model II	Model III
Hypertension	1.51 (1.33–1.72)	1.12 (0.98–1.29)	1.07 (0.93–1.24)
Asthma	1.44 (1.26–1.64)	1.49 (1.30–1.71)	1.29 (1.12–1.49)
Arthritis	4.26 (3.82–4.75)	3.52 (3.12–3.97)	3.07 (2.71–3.48)
Congestive heart failure	3.33 (2.43–4.57)	2.15 (1.55–2.97)	1.72(1.24–2.40)
Coronary heart disease	2.61 (2.03–3.36)	1.69 (1.30–2.20)	1.44 (1.10–1.88)
Angina	3.83 (2.89–5.07)	2.65 (1.98–3.54)	1.73 (1.26–2.38)
Stroke	1.95 (1.48–2.57)	1.39 (1.04–1.84)	1.03 (0.77–1.39)
Emphysema	3.18 (2.26–4.48)	2.11 (1.49–3.00)	1.47 (1.03–2.10)
Chronic bronchitis	2.42 (2.01–2.92)	2.01 (1.66–2.44)	1.64 (1.35–2.00)
Liver disease	2.23 (1.75–2.85)	2.04 (1.58–2.62)	1.77 (1.37–2.29)
Cancer	1.90 (1.60–2.26)	1.26 (1.05–1.51)	1.20 (1.00–1.44)
Diabetes	1.56 (1.34–1.82)	1.24 (1.05–1.46)	1.00 (0.85–1.20)
Renal failure	2.49 (1.86–3.34)	2.25 (1.67–3.04)	1.85 (1.36–2.51)

Notes: Model I: No covariates were included; Model II: Gender, Age, and Ethnicity were adjusted on the basis of Model I; Model III: On the basis of Model II, the education level, poverty income ratio, body mass index, smoking, behavioral patterns (Vigorous exercise, Moderate exercise, Sedentary), Prescription Medication Use and marital status were further adjusted.
Abbreviations: OR, odds ratio; CI, confidence interval.

Risk Factor Analysis of Chronic Pain

Our analysis identified smoking (OR = 1.83, 95% CI: 1.66–2.02), the population aged 65 and above (OR = 2.01, 95% CI: 1.74–2.31), prescription medication use (OR = 2.33, 95% CI: 2.10–2.58) and widowed (OR = 2.13, 95% CI: 1.72–2.65) as significant independent risk factors for chronic pain when compared to non-smokers and normal BMI individuals, respectively. Complete risk factor analyses are presented in Table 4.

Table 4 Analysis of Risk Factors for Chronic Pain

Variables	OR	95% CI	*P*-value
Age			
<65	Ref.	Ref.	Ref.
≥65	2.01	1.74–2.31	<0.001
Gender			
Female	Ref.	Ref.	Ref.
Male	0.82	0.75–0.91	<0.001
Race			
Mexican American	Ref.	Ref.	Ref.
Other Hispanic	0.71	0.56–0.90	0.004
Non-Hispanic White	1.72	1.50–1.98	<0.001
Non-Hispanic Black	1.24	1.05–1.47	0.010
Other Race	0.93	0.71–1.21	0.590
PIR			
<1	Ref.	Ref.	Ref.
1–3	0.93	0.82–1.05	0.251
>3	0.83	0.73–0.95	0.005

(*Continued*)

Table 4 (Continued).

Variables	OR	95% CI	*P*-value
Education			
Less Than 9th Grade	Ref.	Ref.	Ref.
9–11th Grade	1.07	0.88–1.29	0.496
High School Grad	1.07	0.90–1.28	0.424
Some College	1.00	0.85–1.19	0.971
College Graduate or above	0.61	0.51–0.73	<0.001
BMI			
<18.5	Ref.	Ref.	Ref.
18.5–24.9	0.82	0.56–1.21	0.322
≥30	1.05	0.72–1.53	0.799
25.0–29.9	0.96	0.66–1.41	0.848
Vigorous exercise			
No	Ref.	Ref.	Ref.
Yes	1.04	0.93–1.17	0.449
Moderate exercise			
No	Ref.	Ref.	Ref.
Yes	1.04	0.94–1.14	0.457
Sedentary			
No	Ref.	Ref.	Ref.
Yes	0.83	0.72–0.95	0.009
Smoke			
No	Ref.	Ref.	Ref.
Yes	1.83	1.66–2.02	<0.001
Prescription Medication Use			
No	Ref.	Ref.	
Yes	2.33	2.10–2.58	<0.001
Marital Status			
Married	Ref.	Ref.	Ref.
Widowed	2.13	1.72–2.65	<0.001
Divorced	1.28	1.10–1.49	0.002
Separated	0.94	0.73–1.22	0.645
Never married	0.59	0.51–0.68	<0.001
Living with partner	0.92	0.76–1.10	0.353

Abbreviations: OR, odds ratio; CI, confidence interval; Ref, reference; PIR, Poverty income ratio; BMI, body mass index.

Subgroup Analysis of Chronic Pain and Arthritis Comorbidity Risk Factors

Table 5 presents the results of the subgroup analysis exploring the relationship between chronic pain and arthritis, stratified by various factors including age, gender, race and educational level.

Age

The association between chronic pain and arthritis was strongest in individuals <65 years (OR = 4.28, 95% CI: 3.78–4.84, P < 0.001). In contrast, the association was weaker in individuals ≥65 years (OR = 3.26, 95% CI: 2.46–4.32, P < 0.001), indicating a higher comorbidity risk in younger populations.

Gender

No significant gender differences were observed (P = 0.923). Both females (OR = 4.22, 95% CI: 3.64–4.88, P < 0.001) and males (OR = 4.26, 95% CI: 3.61–5.02, P < 0.001) showed similar odds ratios for the comorbidity of chronic pain and arthritis.

Table 5 Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Arthritis

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
All patients	7135 (1000.00)	1337/5127	1206/2008	4.26 (3.82–4.75)	<0.001	
Age						0.083
<65	6245 (87.53)	1222/4778	873/1467	4.28 (3.78–4.84)	<0.001	
≥65	890 (12.47)	115/349	333/541	3.26 (2.46–4.32)	<0.001	
Gender						0.923
Female	3828 (53.65)	731/2667	713/1161	4.22 (3.64–4.88)	<0.001	
Male	3307 (46.35)	606/2460	493/847	4.26 (3.61–5.02)	<0.001	
Race						0.536
Mexican American	1296 (18.16)	231/1009	146/287	3.49 (2.65–4.59)	<0.001	
Other Hispanic	562 (7.88)	78/454	49/108	40.00 (2.55–6.28)	<0.001	
Non-Hispanic White	3629 (50.86)	751/2473	752/1156	4.27 (3.68–4.95)	<0.001	
Non-Hispanic Black	1311 (18.37)	224/922	219/389	4.01 (3.12–5.16)	<0.001	
Other Race	337 (4.72)	53/269	40/68	5.82 (3.30–10.28)	<0.001	
PIR						0.472
<1	1604 (22.48)	317/1142	291/462	4.43 (3.52–5.57)	<0.001	
1–3	2891 (40.52)	539/2066	507/825	4.52 (3.81–5.36)	<0.001	
>3	2640 (370.00)	481/1919	408/721	3.90 (3.26–4.66)	<0.001	
Education						0.392
Less Than 9th Grade	776 (10.88)	130/508	158/268	4.18 (3.05–5.72)	<0.001	
9–11th Grade	1141 (15.99)	204/776	237/365	5.19 (3.97–6.79)	<0.001	
High School Grad	1709 (23.95)	333/1184	330/525	4.32 (3.48–5.38)	<0.001	
Some College degree	2076 (29.10)	440/1524	332/552	3.72 (3.03–4.56)	<0.001	
College Graduate	1433 (20.08)	230/1135	149/298	3.93 (3.01–5.15)	<0.001	
BMI						0.803
<18.5	120 (1.68)	30/96	14/24	3.08 (1.23–7.72)	0.016	
18.5–24.9	1920 (26.91)	369/1500	251/420	4.55 (3.63–5.72)	<0.001	
≥30	2721 (38.14)	463/1779	566/942	4.28 (3.62–5.06)	<0.001	
25.0–29.9	2374 (33.27)	475/1752	375/622	4.08 (3.37–4.95)	<0.001	
Vigorous exercise						0.815
No	5407 (75.78)	974/3822	940/1585	4.26 (3.77–4.82)	<0.001	
Yes	1728 (24.22)	363/1305	266/423	4.40 (3.49–5.54)	<0.001	
Moderate exercise						0.099
No	4096 (57.41)	727/2911	718/1185	4.62 (40.00–5.33)	<0.001	
Yes	3039 (42.59)	610/2216	488/823	3.84 (3.24–4.53)	<0.001	
Sedentary						0.023
No	991 (13.89)	237/735	153/256	3.12 (2.33–4.19)	<0.001	
Yes	6144 (86.11)	1100/4392	1053/1752	4.51 (4.01–5.07)	<0.001	
Smoke						0.028
No	3630 (50.88)	596/2816	452/814	4.65 (3.94–5.49)	<0.001	
Yes	3505 (49.12)	741/2311	754/1194	3.63 (3.14–4.20)	<0.001	
Prescription Medication Use						0.175
No	2987 (41.86)	561/2648	180/339	4.21 (3.34–5.32)	<0.001	
Yes	4148 (58.14)	776/2479	1026/1669	3.50 (3.07–3.99)	<0.001	
Marital Status						0.312
Married	3805 (53.33)	693/2656	687/1149	4.21 (3.64–4.88)	<0.001	
Widowed	361 (5.06)	51/137	147/224	3.22 (2.07–5.01)	<0.001	
Divorced	819 (11.48)	163/517	182/302	3.29 (2.45–4.43)	<0.001	
Separated	278 (3.90)	54/205	43/73	4.01 (2.29–7.02)	<0.001	
Never married	1283 (17.98)	239/1117	82/166	3.59 (2.56–5.02)	<0.001	
Living with partner	589 (8.26)	137/495	65/94	5.86 (3.62–9.46)	<0.001	

Abbreviations: OR, Odds Ratio; CI, Confidence Interval; PIR, Poverty income ratio; BMI, body mass index.

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Race

Significant racial differences were observed, with non-Hispanic White individuals showing the highest odds ratio (OR = 4.27, 95% CI: 3.68–4.95, P < 0.001). The Other Race group had the highest risk (OR = 5.82, 95% CI: 3.30–10.28, P < 0.001), highlighting the role of race in modulating comorbidity risk.

Exercise Behavior

Sedentary individuals exhibited a significantly higher risk of comorbidity (OR = 4.51, 95% CI: 4.01–5.07, P < 0.001), suggesting that physical inactivity increases the risk of chronic pain and arthritis comorbidity.

Smoking Status

Smokers had a lower odds ratio (OR = 3.63, 95% CI: 3.14–4.20, P < 0.001) compared to non-smokers (OR = 4.65, 95% CI: 3.94–5.49, P < 0.001), indicating smoking status significantly affects the comorbidity of chronic pain and arthritis.

Marital Status

Living with a partner was associated with the highest odds ratio for comorbidity (OR = 5.86, 95% CI: 3.62–9.46, P < 0.001), while widowed individuals had a lower OR (OR = 3.22, 95% CI: 2.07–5.01, P < 0.001).

Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Renal Failure

Table 6 presents the results of the subgroup analysis exploring the relationship between chronic pain and renal failure, stratified by various factors. Only statistically significant results are described below.

Table 6 Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Renal Failure

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
All patients	7135 (1000.00)	2434/6945	109/190	2.49 (1.86–3.34)	<0.001	
Age						0.755
<65	6245 (87.53)	2019/6104	76/141	2.37 (1.69–3.31)	<0.001	
≥65	890 (12.47)	415/841	33/49	2.12 (1.15–3.91)	0.016	
Gender						0.376
Female	3828 (53.65)	1389/3731	55/97	2.21 (1.47–3.32)	<0.001	
Male	3307 (46.35)	1045/3214	54/93	2.87 (1.89–4.37)	<0.001	
Race						0.431
Mexican American	1296 (18.16)	360/1261	17/35	2.36 (1.20–4.64)	0.012	
Other Hispanic	562 (7.88)	123/545	4/17	1.06 (0.34–3.30)	0.926	
Non-Hispanic White	3629 (50.86)	1449/3550	54/79	3.13 (1.94–5.06)	<0.001	
Non-Hispanic Black	1311 (18.37)	414/1263	29/48	3.13 (1.73–5.65)	<0.001	
Other Race	337 (4.72)	88/326	5/11	2.25 (0.67–7.57)	0.189	
PIR						0.814
<1	1604 (22.48)	570/1536	38/68	2.15 (1.32–3.50)	0.002	
1–3	2891 (40.52)	998/2809	48/82	2.56 (1.64–40.00)	<0.001	
>3	2640 (370.00)	866/2600	23/40	2.71 (1.44–5.10)	0.002	
Education						0.797
Less Than 9th Grade	776 (10.88)	266/740	22/36	2.80 (1.41–5.56)	0.003	
9–11th Grade	1141 (15.99)	413/1096	28/45	2.72 (1.47–5.04)	0.001	
High School Grad	1709 (23.95)	639/1667	24/42	2.15 (1.15–3.98)	0.016	
Some College degree	2076 (29.10)	744/2022	28/54	1.85 (1.08–3.18)	0.026	
College Graduate	1433 (20.08)	372/1420	7/13	3.29 (1.10–9.84)	0.033	

(*Continued*)

Table 6 (Continued).

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
BMI						0.801
<18.5	120 (1.68)	41/115	3/5	2.71 (0.43–16.87)	0.286	
18.5–24.9	1920 (26.91)	599/1885	21/35	3.22 (1.63–6.38)	<0.001	
≥30	2721 (38.14)	976/2631	53/90	2.43 (1.58–3.72)	<0.001	
25.0–29.9	2374 (33.27)	818/2314	32/60	2.09 (1.25–3.50)	0.005	
Vigorous exercise						0.958
No	5407 (75.78)	1825/5251	89/156	2.49 (1.81–3.44)	<0.001	
Yes	1728 (24.22)	609/1694	20/34	2.55 (1.28–5.08)	0.008	
Moderate exercise						0.808
No	4096 (57.41)	1373/3971	72/125	2.57 (1.79–3.69)	<0.001	
Yes	3039 (42.59)	1061/2974	37/65	2.38 (1.45–3.91)	<0.001	
Sedentary						0.400
No	991 (13.89)	376/965	14/26	1.83 (0.84–3.99)	0.131	
Yes	6144 (86.11)	2058/5980	95/164	2.62 (1.92–3.59)	<0.001	
Smoke						0.636
No	3630 (50.88)	1011/3551	37/79	2.21 (1.41–3.46)	<0.001	
Yes	3505 (49.12)	1423/3394	72/111	2.56 (1.72–3.80)	<0.001	
Prescription Medication Use						0.011
No	2987 (41.86)	721/2954	20/33	4.76 (2.36–9.63)	<0.001	
Yes	4148 (58.14)	1713/3991	89/157	1.74 (1.26–2.40)	<0.001	
Marital Status						0.398
Married	3805 (53.33)	1322/3713	58/92	3.09 (2.01–4.74)	<0.001	
Widowed	361 (5.06)	185/343	13/18	2.22 (0.77–6.36)	0.138	
Divorced	819 (11.48)	328/787	17/32	1.59 (0.78–3.22)	0.202	
Separated	278 (3.90)	94/269	3/9	0.93 (0.23–3.81)	0.921	
Never married	1283 (17.98)	313/1261	8/22	1.73 (0.72–4.16)	0.221	
Living with partner	589 (8.26)	192/572	10/17	2.83 (1.06–7.54)	0.038	

Abbreviations: OR, Odds Ratio; CI, Confidence Interval; PIR, Poverty income ratio; BMI, body mass index.

Age

The association between chronic pain and renal failure was significant in individuals <65 years (OR = 2.37, 95% CI: 1.69–3.31, P < 0.001). However, the association was weaker and not statistically significant in those ≥65 years (OR = 2.12, 95% CI: 1.15–3.91, P = 0.016), suggesting a stronger comorbidity risk in younger individuals.

Gender

Males had a significantly higher risk of comorbidity (OR = 2.87, 95% CI: 1.89–4.37, P < 0.001) compared to females (OR = 2.21, 95% CI: 1.47–3.32, P < 0.001), indicating that males are more likely to experience chronic pain and renal failure comorbidity.

Race

Non-Hispanic White individuals exhibited the highest risk for comorbidity (OR = 3.13, 95% CI: 1.94–5.06, P < 0.001). Mexican Americans also showed a significant association (OR = 2.36, 95% CI: 1.20–4.64, P = 0.012), while Other Hispanic and Other Race groups did not show significant results.

BMI

Individuals with BMI 18.5–24.9 had an (OR = 3.22, 95% CI: 1.63–6.38, P < 0.001), while those with BMI ≥ 30 (OR = 2.43, 95% CI: 1.58–3.72, P < 0.001). Those with BMI 25.0–29.9 (OR = 2.09, 95% CI: 1.25–3.50, P = 0.005), showing a significant association between higher BMI and comorbidity.

Vigorous Exercise

Individuals who engaged in vigorous exercise had a significantly higher OR for comorbidity (OR = 2.55, 95% CI: 1.28–5.08, P = 0.008), suggesting that exercise intensity plays a role in the comorbidity risk.

Smoking

Smokers showed a significantly higher OR for comorbidity (OR = 2.56, 95% CI: 1.72–3.80, P < 0.001), compared to non-smokers (OR = 2.21, 95% CI: 1.41–3.46, P < 0.001), highlighting the influence of smoking on the risk of comorbidity.

Prescription Medication Use

Non-users of prescription medication had a significantly higher OR (OR = 4.76, 95% CI: 2.36–9.63, P < 0.001), while prescription medication users (OR = 1.74, 95% CI: 1.26–2.40, P < 0.001), indicating a differential impact of medication use on comorbidity risk.

Marital Status

Living with a partner showed the highest OR for comorbidity (OR = 2.83, 95% CI: 1.06–7.54, P = 0.038), suggesting that partnership status influences the comorbidity risk between chronic pain and renal failure.

Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Liver Disease

Table 7 presents the results of the subgroup analysis examining the relationship between chronic pain and liver disease, stratified by age, gender, race, educational level, BMI, and other factors. Only statistically significant results are described below.

Table 7 Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Liver Disease

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
All patients	7135 (1000.00)	2396/6865	147/270	2.23 (1.75–2.85)	<0.001	
Age						0.266
<65	6245 (87.53)	1968/6008	127/237	2.37 (1.83–3.08)	<0.001	
≥65	890 (12.47)	428/857	20/33	1.54 (0.76–3.14)	0.232	
Gender						0.424
Female	3828 (53.65)	1373/3698	71/130	2.04 (1.43–2.90)	<0.001	
Male	3307 (46.35)	1023/3167	76/140	2.49 (1.77–3.50)	<0.001	
Race						0.471
Mexican American	1296 (18.16)	356/1243	21/53	1.64 (0.93–2.87)	0.088	
Other Hispanic	562 (7.88)	118/537	9/25	20.00 (0.86–4.63)	0.107	
Non-Hispanic White	3629 (50.86)	1406/3480	97/149	2.75 (1.95–3.88)	<0.001	
Non-Hispanic Black	1311 (18.37)	429/1280	14/31	1.63 (0.80–3.35)	0.180	
Other Race	337 (4.72)	87/325	6/12	2.74 (0.86–8.71)	0.088	
PIR						0.076
<1	1604 (22.48)	564/1530	44/74	2.51 (1.56–4.04)	<0.001	
1–3	2891 (40.52)	979/2780	67/111	2.80 (1.90–4.13)	<0.001	
>3	2640 (370.00)	853/2555	36/85	1.47 (0.95–2.27)	0.087	
Education						0.780
Less Than 9th Grade	776 (10.88)	267/735	21/41	1.84 (0.98–3.46)	0.058	
9–11th Grade	1141 (15.99)	415/1100	26/41	2.86 (1.50–5.46)	0.001	
High School Grad	1709 (23.95)	624/1644	39/65	2.45 (1.48–4.07)	<0.001	
Some College degree	2076 (29.10)	726/1993	46/83	2.17 (1.39–3.38)	<0.001	
College Graduate	1433 (20.08)	364/1393	15/40	1.70 (0.88–3.25)	0.112	

(*Continued*)

Table 7 (Continued).

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
BMI						0.669
<18.5	120 (1.68)	41/112	3/8	1.04 (0.24–4.57)	0.960	
18.5–24.9	1920 (26.91)	588/1862	32/58	2.67 (1.57–4.52)	<0.001	
≥30	2721 (38.14)	968/2612	61/109	2.16 (1.47–3.18)	<0.001	
25.0–29.9	2374 (33.27)	799/2279	51/95	2.15 (1.42–3.24)	<0.001	
Vigorous exercise						0.242
No	5407 (75.78)	1799/5188	115/219	2.08 (1.59–2.73)	<0.001	
Yes	1728 (24.22)	597/1677	32/51	3.05 (1.71–5.42)	<0.001	
Moderate exercise						0.772
No	4096 (57.41)	1359/3939	86/157	2.30 (1.67–3.17)	<0.001	
Yes	3039 (42.59)	1037/2926	61/113	2.14 (1.46–3.12)	<0.001	
Sedentary						0.223
No	991 (13.89)	368/947	22/44	1.57 (0.86–2.88)	0.142	
Yes	6144 (86.11)	2028/5918	125/226	2.37 (1.82–3.10)	<0.001	
Smoke						0.141
No	3630 (50.88)	1005/3523	43/107	1.68 (1.14–2.49)	0.009	
Yes	3505 (49.12)	1391/3342	104/163	2.47 (1.78–3.43)	<0.001	
Prescription Medication Use						0.388
No	2987 (41.86)	715/2927	26/60	2.37 (1.41–3.97)	0.001	
Yes	4148 (58.14)	1681/3938	121/210	1.83 (1.38–2.42)	<0.001	
Marital Status						0.266
Married	3805 (53.33)	1307/3665	73/140	1.97 (1.40–2.76)	<0.001	
Widowed	361 (5.06)	188/347	10/14	2.11 (0.65–6.87)	0.213	
Divorced	819 (11.48)	311/764	34/55	2.36 (1.34–4.14)	0.003	
Separated	278 (3.90)	92/264	5/14	1.04 (0.34–3.19)	0.947	
Never married	1283 (17.98)	309/1253	12/30	2.04 (0.97–4.28)	0.060	
Living with partner	589 (8.26)	189/572	13/17	6.59 (2.12–20.47)	0.001	

Abbreviations: OR, Odds Ratio; CI, Confidence Interval; PIR, Poverty income ratio; BMI, body mass index.

Age

The association between chronic pain and liver disease was significant in individuals <65 years (OR = 2.37, 95% CI: 1.83–3.08, P < 0.001). However, the association was weaker and not statistically significant in those ≥65 years (OR = 1.54, 95% CI: 0.76–3.14, P = 0.232), suggesting that younger individuals have a higher comorbidity risk.

Gender

Males exhibited a significantly higher risk for comorbidity (OR = 2.49, 95% CI: 1.77–3.50, P < 0.001) compared to females (OR = 2.04, 95% CI: 1.43–2.90, P < 0.001).

Race

Non-Hispanic White individuals showed the highest odds ratio for comorbidity (OR = 2.75, 95% CI: 1.95–3.88, P < 0.001), while Other Hispanic and Other Race groups did not show significant results.

BMI

Individuals with BMI 18.5–24.9 exhibited the highest OR for comorbidity (OR = 2.67, 95% CI: 1.57–4.52, P < 0.001). BMI ≥ 30 individuals (OR = 2.16, 95% CI: 1.47–3.18, P < 0.001), and those with BMI 25.0–29.9 (OR = 2.15, 95% CI: 1.42–3.24, P < 0.001).

Vigorous Exercise

Vigorous exercise was significantly associated with comorbidity (OR = 3.05, 95% CI: 1.71–5.42, P < 0.001), suggesting that exercise intensity increases the comorbidity risk between chronic pain and liver disease.

Smoking

Smokers had a significantly higher OR for comorbidity (OR = 2.47, 95% CI: 1.78–3.43, P < 0.001) compared to non-smokers (OR = 1.68, 95% CI: 1.14–2.49, P = 0.009), highlighting the impact of smoking on comorbidity risk.

Prescription Medication Use

Non-users of prescription medication had the highest OR (OR = 2.37, 95% CI: 1.41–3.97, P = 0.001) compared to those using prescription medications (OR = 1.83, 95% CI: 1.38–2.42, P < 0.001).

Marital Status

Living with a partner showed the highest OR for comorbidity (OR = 6.59, 95% CI: 2.12–20.47, P = 0.001), suggesting that living arrangement status significantly influences the comorbidity of chronic pain and liver disease.

Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Angina

Table 8 presents the results of the subgroup analysis examining the relationship between chronic pain and angina, stratified by age, gender, race, educational level, BMI, and other factors. Only statistically significant results are described below.

Table 8 Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Angina

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
All patients	7135 (100.00)	2391/6908	152/227	3.83 (2.89–5.07)	<0.001	
Age						0.202
<65	6245 (87.53)	2011/6115	84/130	3.73 (2.59–5.36)	<0.001	
≥65	890 (12.47)	380/793	68/97	2.55 (1.61–4.02)	<0.001	
Gender						0.640
Female	3828 (53.65)	1372/3722	72/106	3.63 (2.40–5.48)	<0.001	
Male	3307 (46.35)	1019/3186	80/121	4.15 (2.83–6.09)	<0.001	
Race						0.345
Mexican American	1296 (18.16)	359/1258	18/38	2.25 (1.18–4.31)	0.014	
Other Hispanic	562 (7.88)	122/554	5/8	5.90 (1.39–25.04)	0.016	
Non-Hispanic White	3629 (50.86)	1405/3491	98/138	3.64 (2.50–5.29)	<0.001	
Non-Hispanic Black	1311 (18.37)	420/1280	23/31	5.89 (2.61–13.27)	<0.001	
Other Race	337 (4.72)	85/325	8/12	5.65 (1.66–19.23)	0.006	
PIR						0.198
<1	1604 (22.48)	569/1549	39/55	4.20 (2.32–7.58)	<0.001	
1–3	2891 (40.52)	974/2791	72/100	4.80 (3.08–7.47)	<0.001	
>3	2640 (37.00)	848/2568	41/72	2.68 (1.67–4.31)	<0.001	
Education						0.865
Less Than 9th Grade	776 (10.88)	265/742	23/34	3.76 (1.81–7.84)	<0.001	
9–11th Grade	1141 (15.99)	414/1099	27/42	2.98 (1.57–5.66)	<0.001	
High School Grad	1709 (23.95)	623/1654	40/55	4.41 (2.42–8.05)	<0.001	
Some College degree	2076 (29.10)	731/2014	41/62	3.43 (2.01–5.84)	<0.001	
College Graduate	1433 (20.08)	358/1399	21/34	4.70 (2.33–9.48)	<0.001	

(*Continued*)

Table 8 (Continued).

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
BMI						0.339
<18.5	120 (1.68)	42/117	2/3	3.57 (0.31–40.57)	0.305	
18.5–24.9	1920 (26.91)	591/1881	29/39	6.33 (3.06–13.07)	<0.001	
≥30	2721 (38.14)	946/2599	83/122	3.72 (2.52–5.49)	<0.001	
25.0–29.9	2374 (33.27)	812/2311	38/63	2.81 (1.68–4.68)	<0.001	
Vigorous exercise						0.122
No	5407 (75.78)	1799/5228	115/179	3.42 (2.51–4.67)	<0.001	
Yes	1728 (24.22)	592/1680	37/48	6.18 (3.13–12.21)	<0.001	
Moderate exercise						0.299
No	4096 (57.41)	1345/3951	100/145	4.31 (3.01–6.16)	<0.001	
Yes	3039 (42.59)	1046/2957	52/82	3.17 (2.01–4.99)	<0.001	
Sedentary						0.123
No	991 (13.89)	375/965	15/26	2.15 (0.97–4.72)	0.058	
Yes	6144 (86.11)	2016/5943	137/201	4.17 (3.08–5.64)	<0.001	
Smoke						0.218
No	3630 (50.88)	992/3542	56/88	4.50 (2.90–6.99)	<0.001	
Yes	3505 (49.12)	1399/3366	96/139	3.14 (2.18–4.53)	<0.001	
Prescription Medication Use						0.008
No	2987 (41.86)	728/2972	13/15	20.04 (4.51–88.99)	<0.001	
Yes	4148 (58.14)	1663/3936	139/212	2.60 (1.95–3.48)	<0.001	
Marital Status						0.230
Married	3805 (53.33)	1295/3669	85/136	3.06 (2.15–4.35)	<0.001	
Widowed	361 (5.06)	176/334	22/27	3.95 (1.46–10.68)	0.007	
Divorced	819 (11.48)	318/779	27/40	3.01 (1.53–5.92)	0.001	
Separated	278 (3.90)	86/266	11/12	23.02 (2.93–181.06)	0.003	
Never married	1283 (17.98)	318/1276	3/7	2.26 (0.50–10.15)	0.288	
Living with partner	589 (8.26)	198/584	4/5	7.80 (0.87–70.24)	0.067	

Abbreviations: OR, Odds Ratio; CI, Confidence Interval; PIR, Poverty income ratio; BMI, body mass index.

Age

The association between chronic pain and angina was significant in individuals <65 years (OR = 3.73, 95% CI: 2.59–5.36, P < 0.001). However, the association was weaker and not statistically significant in individuals ≥65 years (OR = 2.55, 95% CI: 1.61–4.02, P = 0.232), suggesting a stronger comorbidity risk in younger individuals.

Gender

Males exhibited a significantly higher risk for comorbidity (OR = 4.15, 95% CI: 2.83–6.09, P < 0.001) compared to females (OR = 3.63, 95% CI: 2.40–5.48, P < 0.001).

Race

Non-Hispanic White individuals had the highest risk for comorbidity with an (OR = 3.64, 95% CI: 2.50–5.29, P < 0.001). Mexican Americans also showed a significant association (OR = 2.25, 95% CI: 1.18–4.31, P = 0.014), while Other Hispanic and Other Race groups did not show significant results.

BMI

Individuals with BMI 18.5–24.9 had the highest odds of comorbidity (OR = 6.33, 95% CI: 3.06–13.07, P < 0.001). Those with BMI ≥ 30 (OR = 3.72, 95% CI: 2.52–5.49, P < 0.001), and individuals with BMI 25.0–29.9 (OR = 2.81, 95% CI: 1.68–4.68, P < 0.001).

Vigorous Exercise

Vigorous exercise was significantly associated with a higher OR for comorbidity (OR = 6.18, 95% CI: 3.13–12.21, P < 0.001), suggesting that exercise intensity plays a critical role in the comorbidity risk between chronic pain and angina.

Prescription Medication Use

Non-users of prescription medication had the highest OR (OR = 20.04, 95% CI: 4.51–88.99, P < 0.001) compared to those using prescription medications (OR = 2.60, 95% CI: 1.95–3.48, P < 0.001), highlighting a differential impact of medication use on the risk of comorbidity.

Marital Status

Widowed individuals showed a significantly higher OR (OR = 3.95, 95% CI: 1.46–10.68, P = 0.007), while divorced individuals also had a significant association (OR = 3.01, 95% CI: 1.53–5.92, P = 0.001).

Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Congestive Heart

Table 9 presents the results of the subgroup analysis examining the relationship between chronic pain and congestive heart failure, stratified by various factors such as age, gender, race, educational level, BMI, and other factors. Only statistically significant results are described below.

Table 9 Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Congestive Heart Failure

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
All patients	7135 (1000.00)	2432/6962	111/173	3.33 (2.43–4.57)	<0.001	
Age						0.631
<65	6245 (87.53)	2040/6152	55/93	2.92 (1.92–4.43)	<0.001	
≥65	890 (12.47)	392/810	56/80	2.49 (1.51–4.09)	<0.001	
Gender						0.701
Female	3828 (53.65)	1392/3752	52/76	3.67 (2.25–5.99)	<0.001	
Male	3307 (46.35)	1040/3210	59/97	3.24 (2.14–4.90)	<0.001	
Race						0.484
Mexican American	1296 (18.16)	370/1277	7/19	1.43 (0.56–3.66)	0.456	
Other Hispanic	562 (7.88)	124/555	3/7	2.61 (0.58–11.80)	0.214	
Non-Hispanic White	3629 (50.86)	1428/3524	75/105	3.67 (2.39–5.63)	<0.001	
Non-Hispanic Black	1311 (18.37)	418/1271	25/40	3.40 (1.77–6.52)	<0.001	
Other Race	337 (4.72)	92/335	1/2	2.64 (0.16–42.67)	0.494	
PIR						0.349
<1	1604 (22.48)	577/1553	31/51	2.62 (1.48–4.64)	<0.001	
1–3	2891 (40.52)	999/2816	47/75	3.05 (1.90–4.91)	<0.001	
>3	2640 (370.00)	856/2593	33/47	4.78 (2.55–8.99)	<0.001	
Education						0.327
Less Than 9th Grade	776 (10.88)	271/745	17/31	2.12 (1.03–4.38)	0.041	
9–11th Grade	1141 (15.99)	411/1101	30/40	5.04 (2.44–10.41)	<0.001	
High School Grad	1709 (23.95)	633/1667	30/42	4.08 (2.08–8.03)	<0.001	
Some College degree	2076 (29.10)	747/2032	25/44	2.26 (1.24–4.14)	0.008	
College Graduate	1433 (20.08)	370/1417	9/16	3.64 (1.35–9.84)	0.011	
BMI						0.827
<18.5	120 (1.68)	43/119	1/1	10,176,599.47 (00.00–Inf)	0.991	
18.5–24.9	1920 (26.91)	601/1889	19/31	3.39 (1.64–7.04)	0.001	
≥30	2721 (38.14)	970/2630	59/91	3.16 (2.04–4.89)	<0.001	
25.0–29.9	2374 (33.27)	818/2324	32/50	3.27 (1.83–5.87)	<0.001	

(*Continued*)

Table 9 (Continued).

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
Vigorous exercise						0.180
No	5407 (75.78)	1823/5260	91/147	3.06 (2.19–4.29)	<0.001	
Yes	1728 (24.22)	609/1702	20/26	5.98 (2.39–14.98)	<0.001	
Moderate exercise						0.755
No	4096 (57.41)	1372/3983	73/113	3.47 (2.35–5.14)	<0.001	
Yes	3039 (42.59)	1060/2979	38/60	3.13 (1.84–5.31)	<0.001	
Sedentary						0.575
No	991 (13.89)	376/972	14/19	4.44 (1.59–12.42)	0.005	
Yes	6144 (86.11)	2056/5990	97/154	3.26 (2.34–4.54)	<0.001	
Smoke						0.400
No	3630 (50.88)	1016/3576	32/54	3.66 (2.12–6.34)	<0.001	
Yes	3505 (49.12)	1416/3386	79/119	2.75 (1.87–4.04)	<0.001	
Prescription Medication Use						0.199
No	2987 (41.86)	735/2978	6/9	6.10 (1.52–24.47)	0.011	
Yes	4148 (58.14)	1697/3984	105/164	2.40 (1.73–3.32)	<0.001	
Marital Status						0.241
Married	3805 (53.33)	1326/3716	54/89	2.78 (1.81–4.28)	<0.001	
Widowed	361 (5.06)	172/326	26/35	2.59 (1.18–5.69)	0.018	
Divorced	819 (11.48)	331/797	14/22	2.46 (1.02–5.94)	0.045	
Separated	278 (3.90)	90/270	7/8	140.00 (1.70–115.53)	0.014	
Never married	1283 (17.98)	317/1271	4/12	1.50 (0.45–5.03)	0.507	
Living with partner	589 (8.26)	196/582	6/7	11.82 (1.41–98.84)	0.023	

Abbreviations: OR, Odds Ratio; CI, Confidence Interval; PIR, Poverty income ratio; BMI, body mass index.

Age

The association between chronic pain and congestive heart failure was significant in individuals <65 years (OR = 2.92, 95% CI: 1.92–4.43, P < 0.001). In those ≥65 years, the association remained significant (OR = 2.49, 95% CI: 1.51–4.09, P < 0.001), though the odds ratio was slightly lower.

Gender

Females exhibited a significantly higher risk of comorbidity (OR = 3.67, 95% CI: 2.25–5.99, P < 0.001) compared to males (OR = 3.24, 95% CI: 2.14–4.90, P < 0.001).

Race

Non-Hispanic White individuals had the highest odds ratio for comorbidity (OR = 3.64, 95% CI: 2.39–5.63, P < 0.001). Non-Hispanic Black individuals also showed a significant association (OR = 3.40, 95% CI: 1.77–6.52, P < 0.001), while Mexican Americans and Other Hispanic groups did not exhibit statistically significant results.

BMI

Individuals with BMI 18.5–24.9 had the highest odds of comorbidity (OR = 3.39, 95% CI: 1.64–7.04, P < 0.001). Those with BMI ≥ 30 (OR = 3.16, 95% CI: 2.04–4.89, P < 0.001), and individuals with BMI 25.0–29.9 (OR = 3.27, 95% CI: 1.83–5.87, P < 0.001).

Vigorous Exercise

Vigorous exercise was significantly associated with a higher OR for comorbidity (OR = 5.98, 95% CI: 2.39–14.98, P < 0.001), suggesting that higher-intensity exercise increases the comorbidity risk between chronic pain and congestive heart failure.

Prescription Medication Use

Non-users of prescription medication had the highest OR (OR = 6.10, 95% CI: 1.52–24.47, P = 0.011) compared to those using prescription medications (OR = 2.40, 95% CI: 1.73–3.32, P < 0.001).

Marital Status

Widowed individuals had a significantly higher OR for comorbidity (OR = 2.59, 95% CI: 1.18–5.69, P = 0.018). Divorced individuals also had a significant association (OR = 2.46, 95% CI: 1.02–5.94, P = 0.045). Additionally, separated individuals exhibited an exceptionally high OR (OR = 140.00, 95% CI: 1.70–115.53, P = 0.014), although this result should be interpreted cautiously due to the small sample size.

Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Chronic Bronchitis

Table 10 presents the results of the subgroup analysis examining the relationship between chronic pain and chronic bronchitis, stratified by various factors, including age, gender, race, educational level, BMI, and other factors. Only statistically significant results are described below:

Table 10 Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Chronic Bronchitis

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
All patients	7135 (1000.00)	2269/6643	274/492	2.42 (2.01–2.92)	<0.001	
Age						0.117
<65	6245 (87.53)	1878/5845	217/400	2.50 (2.04–3.07)	<0.001	
≥65	890 (12.47)	391/798	57/92	1.70 (1.09–2.64)	0.020	
Gender						0.428
Female	3828 (53.65)	1244/3483	200/345	2.48 (1.98–3.11)	<0.001	
Male	3307 (46.35)	1025/3160	74/147	2.11 (1.52–2.94)	<0.001	
Race						0.146
Mexican American	1296 (18.16)	357/1258	20/38	2.80 (1.47–5.36)	0.002	
Other Hispanic	562 (7.88)	118/543	9/19	3.24 (1.29–8.16)	0.013	
Non-Hispanic White	3629 (50.86)	1326/3316	177/313	1.95 (1.55–2.47)	<0.001	
Non-Hispanic Black	1311 (18.37)	391/1214	52/97	2.43 (1.60–3.69)	<0.001	
Other Race	337 (4.72)	77/312	16/25	5.43 (2.30–12.77)	<0.001	
PIR						0.070
<1	1604 (22.48)	516/1458	92/146	3.11 (2.19–4.43)	<0.001	
1–3	2891 (40.52)	927/2681	119/210	2.47 (1.86–3.29)	<0.001	
>3	2640 (370.00)	826/2504	63/136	1.75 (1.24–2.48)	0.002	
Education						0.063
Less Than 9th Grade	776 (10.88)	264/735	24/41	2.52 (1.33–4.77)	0.005	
9–11th Grade	1141 (15.99)	371/1039	70/102	3.94 (2.54–6.10)	<0.001	
High School Grad	1709 (23.95)	596/1585	67/124	1.95 (1.35–2.82)	<0.001	
Some College degree	2076 (29.10)	685/1923	87/153	2.38 (1.71–3.32)	<0.001	
College Graduate	1433 (20.08)	353/1361	26/72	1.61 (0.98–2.65)	0.059	
BMI						0.910
<18.5	120 (1.68)	35/105	9/15	30.00 (0.99–9.10)	0.052	
18.5–24.9	1920 (26.91)	560/1807	60/113	2.52 (1.72–3.70)	<0.001	
≥30	2721 (38.14)	890/2472	139/249	2.25 (1.73–2.92)	<0.001	
25.0–29.9	2374 (33.27)	784/2259	66/115	2.53 (1.73–3.70)	<0.001	
Vigorous exercise						0.386
No	5407 (75.78)	1706/5039	208/368	2.54 (2.05–3.15)	<0.001	
Yes	1728 (24.22)	563/1604	66/124	2.10 (1.46–3.04)	<0.001	

(*Continued*)

Table 10 (Continued).

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
Moderate exercise						0.236
No	4096 (57.41)	1285/3818	160/278	2.67 (2.09–3.42)	<0.001	
Yes	3039 (42.59)	984/2825	114/214	2.13 (1.61–2.82)	<0.001	
Sedentary						0.343
No	991 (13.89)	354/925	36/66	1.94 (1.17–3.20)	0.010	
Yes	6144 (86.11)	1915/5718	238/426	2.51 (2.06–3.07)	<0.001	
Smoke						0.836
No	3630 (50.88)	964/3452	84/178	2.31 (1.70–3.12)	<0.001	
Yes	3505 (49.12)	1305/3191	190/314	2.21 (1.75–2.81)	<0.001	
Prescription Medication Use						0.903
No	2987 (41.86)	708/2902	33/85	1.97 (1.26–3.07)	0.003	
Yes	4148 (58.14)	1561/3741	241/407	2.03 (1.65–2.50)	<0.001	
Marital Status						0.157
Married	3805 (53.33)	1260/3576	120/229	2.02 (1.55–2.65)	<0.001	
Widowed	361 (5.06)	171/319	27/42	1.56 (0.80–3.04)	0.194	
Divorced	819 (11.48)	288/740	57/79	4.07 (2.43–6.80)	<0.001	
Separated	278 (3.90)	79/248	18/30	3.21 (1.47–6.98)	0.003	
Never married	1283 (17.98)	290/1212	31/71	2.46 (1.51–4.01)	<0.001	
Living with partner	589 (8.26)	181/548	21/41	2.13 (1.13–4.03)	0.020	

Abbreviations: OR, Odds Ratio; CI, Confidence Interval; PIR, Poverty income ratio; BMI, body mass index.

Age

The association between chronic pain and chronic bronchitis was significant in individuals <65 years (OR = 2.50, 95% CI: 2.04–3.07, P < 0.001). In those ≥65 years, the association remained significant but weaker (OR = 1.70, 95% CI: 1.09–2.64, P = 0.020), indicating a higher comorbidity risk in younger individuals.

Gender

Females exhibited a significantly higher risk for comorbidity (OR = 2.48, 95% CI: 1.98–3.11, P < 0.001) compared to males (OR = 2.11, 95% CI: 1.52–2.94, P < 0.001).

Race

Non-Hispanic White individuals (OR = 1.95, 95% CI: 1.55–2.47, P < 0.001). Mexican Americans also had a significant association (OR = 2.80, 95% CI: 1.47–5.36, P = 0.002), while Other Race individuals showed a higher OR (OR = 5.43, 95% CI: 2.30–12.77, P < 0.001).

BMI

Individuals with BMI 18.5–24.9 had the highest odds of comorbidity (OR = 2.52, 95% CI: 1.72–3.70, P < 0.001). BMI ≥ 30 individuals (OR = 2.25, 95% CI: 1.73–2.92, P < 0.001), and those with BMI 25.0–29.9 (OR = 2.53, 95% CI: 1.73–3.70, P < 0.001).

Vigorous Exercise

Vigorous exercise was significantly associated with a higher OR for comorbidity (OR = 2.10, 95% CI: 1.46–3.04, P < 0.001), indicating that higher-intensity exercise increases the comorbidity risk between chronic pain and chronic bronchitis.

Marital Status

Divorced individuals had a significantly higher OR (OR = 4.07, 95% CI: 2.43–6.80, P < 0.001), while separated individuals also showed a higher risk (OR = 3.21, 95% CI: 1.47–6.98, P = 0.003). Never married individuals (OR = 2.46, 95% CI: 1.51–4.01, P < 0.001).

Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Emphysema

Table 11 presents the results of the subgroup analysis examining the relationship between chronic pain and emphysema, stratified by age, gender, race, educational level, BMI, and other factors. Only statistically significant results are described below.

Table 11 Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Emphysema

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
All patients	7135 (1000.00)	2452/6991	91/144	3.18 (2.26–4.48)	<0.001	
Age						0.241
<65	6245 (87.53)	2040/6155	55/90	3.17 (2.07–4.86)	<0.001	
≥65	890 (12.47)	412/836	36/54	2.06 (1.15–3.68)	0.015	
Gender						0.648
Female	3828 (53.65)	1400/3759	44/69	2.97 (1.81–4.87)	<0.001	
Male	3307 (46.35)	1052/3232	47/75	3.48 (2.17–5.59)	<0.001	
Race						0.159
Mexican American	1296 (18.16)	375/1288	2/8	0.81 (0.16–4.04)	0.799	
Other Hispanic	562 (7.88)	123/556	4/6	7.04 (1.27–38.89)	0.025	
Non-Hispanic White	3629 (50.86)	1432/3529	71/100	3.59 (2.32–5.55)	<0.001	
Non-Hispanic Black	1311 (18.37)	433/1289	10/22	1.65 (0.71–3.84)	0.248	
Other Race	337 (4.72)	89/329	4/8	2.70 (0.66–11.01)	0.167	
PIR						0.220
<1	1604 (22.48)	578/1562	30/42	4.26 (2.16–8.38)	<0.001	
1–3	2891 (40.52)	1003/2815	43/76	2.35 (1.49–3.73)	<0.001	
>3	2640 (370.00)	871/2614	18/26	4.50 (1.95–10.40)	<0.001	
Education						0.257
Less Than 9th Grade	776 (10.88)	278/754	10/22	1.43 (0.61–3.35)	0.414	
9–11th Grade	1141 (15.99)	413/1099	28/42	3.32 (1.73–6.38)	<0.001	
High School Grad	1709 (23.95)	636/1670	27/39	3.66 (1.84–7.27)	<0.001	
Some College degree	2076 (29.10)	752/2043	20/33	2.64 (1.31–5.34)	0.007	
College Graduate	1433 (20.08)	373/1425	6/8	8.46 (1.70–42.10)	0.009	
BMI						0.855
<18.5	120 (1.68)	41/114	3/6	1.78 (0.34–9.23)	0.492	
18.5–24.9	1920 (26.91)	593/1877	27/43	3.65 (1.95–6.83)	<0.001	
≥30	2721 (38.14)	995/2670	34/51	3.37 (1.87–6.06)	<0.001	
25.0–29.9	2374 (33.27)	823/2330	27/44	2.91 (1.58–5.37)	<0.001	
Vigorous exercise						0.488
No	5407 (75.78)	1840/5292	74/115	3.39 (2.30–4.98)	<0.001	
Yes	1728 (24.22)	612/1699	17/29	2.52 (1.19–5.30)	0.015	
Moderate exercise						0.381
No	4096 (57.41)	1391/4014	54/82	3.64 (2.29–5.77)	<0.001	
Yes	3039 (42.59)	1061/2977	37/62	2.67 (1.60–4.46)	<0.001	

(*Continued*)

Table 11 (Continued).

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
Sedentary						0.285
No	991 (13.89)	383/978	7/13	1.81 (0.60–5.43)	0.288	
Yes	6144 (86.11)	2069/6013	84/131	3.41 (2.37–4.89)	<0.001	
Smoke						0.701
No	3630 (50.88)	1045/3623	3/7	1.85 (0.41–8.28)	0.421	
Yes	3505 (49.12)	1407/3368	88/137	2.50 (1.75–3.57)	<0.001	
Prescription Medication Use						0.083
No	2987 (41.86)	739/2976	2/11	0.67 (0.15–3.12)	0.613	
Yes	4148 (58.14)	1713/4015	89/133	2.72 (1.88–3.92)	<0.001	
Marital Status						0.846
Married	3805 (53.33)	1341/3738	39/67	2.49 (1.53–4.06)	<0.001	
Widowed	361 (5.06)	180/337	18/24	2.62 (1.01–6.76)	0.047	
Divorced	819 (11.48)	323/788	22/31	3.52 (1.60–7.74)	0.002	
Separated	278 (3.90)	91/270	6/8	5.90 (1.17–29.82)	0.032	
Never married	1283 (17.98)	318/1275	3/8	1.81 (0.43–7.60)	0.420	
Living with partner	589 (8.26)	199/583	3/6	1.93 (0.39–9.65)	0.423	

Abbreviations: OR, Odds Ratio; CI, Confidence Interval; PIR, Poverty income ratio; BMI, body mass index.

Age

The association between chronic pain and emphysema was significant in individuals <65 years (OR = 3.17, 95% CI: 2.07–4.86, P < 0.001). For individuals ≥65 years, the association remained significant but weaker (OR = 2.06, 95% CI: 1.15–3.68, P = 0.015), indicating a higher comorbidity risk in younger individuals.

Gender

Gender: Males had a significantly higher risk for comorbidity (OR = 3.48, 95% CI: 2.17–5.59, P < 0.001) compared to females (OR = 2.97, 95% CI: 1.81–4.87, P < 0.001).

Race

Non-Hispanic White individuals had the highest odds ratio for comorbidity (OR = 3.59, 95% CI: 2.32–5.55, P < 0.001). Other Hispanic individuals also showed a significant association (OR = 7.04, 95% CI: 1.27–38.89, P = 0.025), while Mexican Americans and Other Race groups did not exhibit statistically significant results.

BMI

Individuals with BMI 18.5–24.9 exhibited the highest odds of comorbidity (OR = 3.65, 95% CI: 1.95–6.83, P < 0.001). Those with BMI ≥ 30 (OR = 3.37, 95% CI: 1.87–6.06, P < 0.001), and individuals with BMI 25.0–29.9 (OR = 2.91, 95% CI: 1.58–5.37, P < 0.001).

Vigorous Exercise

Vigorous exercise was significantly associated with a higher OR for comorbidity (OR = 2.52, 95% CI: 1.19–5.30, P = 0.015), indicating that individuals who engage in more intense exercise are at higher risk of chronic pain and emphysema comorbidity.

Prescription Medication Use

Prescription medication users had the highest OR for comorbidity (OR = 2.72, 95% CI: 1.88–3.92, P < 0.001), while non-users of prescription medications did not exhibit statistically significant results.

Marital Status

Divorced individuals had a significantly higher OR for comorbidity (OR = 3.52, 95% CI: 1.60–7.74, P = 0.002). Additionally, separated individuals showed a significantly higher risk (OR = 5.90, 95% CI: 1.17–29.82, P = 0.032).

Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Coronary Heart Disease

Table 12 presents the results of the subgroup analysis examining the comorbid risk factors for chronic pain and coronary heart disease, stratified by various sociodemographic and health factors. The following is the analysis of statistically significant results (P-value < 0.05 and CI does not include 1), highlighting the risk factors associated with chronic pain in individuals with coronary heart disease.

Table 12 Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Coronary Heart Disease

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
All patients	7135 (100.00)	2391/6874	152/261	2.61 (2.03–3.36)	<0.001	
Age						0.059
<65	6245 (87.53)	2016/6105	79/140	2.63 (1.87–3.68)	<0.001	
≥65	890 (12.47)	375/769	73/121	1.60 (1.08–2.36)	0.019	
Gender						0.311
Female	3828 (53.65)	1387/3742	57/86	3.34 (2.12–5.24)	<0.001	
Male	3307 (46.35)	1004/3132	95/175	2.52 (1.85–3.42)	<0.001	
Race						0.560
Mexican American	1296 (18.16)	364/1267	13/29	2.02 (0.96–4.23)	0.064	
Other Hispanic	562 (7.88)	125/552	2/10	0.85 (0.18–4.07)	0.843	
Non-Hispanic White	3629 (50.86)	1397/3460	106/169	2.48 (1.81–3.42)	<0.001	
Non-Hispanic Black	1311 (18.37)	418/1269	25/42	2.99 (1.60–5.61)	<0.001	
Other Race	337 (4.72)	87/326	6/11	3.30 (0.98–11.08)	0.054	
PIR						0.178
<1	1604 (22.48)	570/1549	38/55	3.84 (2.15–6.86)	<0.001	
1–3	2891 (40.52)	983/2787	63/104	2.82 (1.89–4.21)	<0.001	
>3	2640 (37.00)	838/2538	51/102	2.03 (1.36–3.02)	<0.001	
Education						0.661
Less Than 9th Grade	776 (10.88)	261/732	27/44	2.87 (1.53–5.36)	<0.001	
9-11th Grade	1141 (15.99)	407/1085	34/56	2.57 (1.49–4.46)	<0.001	
High School Grad	1709 (23.95)	633/1664	30/45	3.26 (1.74–6.10)	<0.001	
Some College degree	2076 (29.10)	736/2008	36/68	1.94 (1.20–3.16)	00.007	
College Graduate	1433 (20.08)	354/1385	25/48	3.17 (1.77–5.65)	<0.001	
BMI						0.455
<18.5	120 (1.68)	42/118	2/2	10,418,899.46 (0.00–Inf)	0.987	
18.5–24.9	1920 (26.91)	591/1864	29/56	2.31 (1.36–3.94)	0.002	
≥30	2721 (38.14)	955/2595	74/126	2.44 (1.70–3.52)	<0.001	
25.0–29.9	2374 (33.27)	803/2297	47/77	2.91 (1.83–4.64)	<0.001	
Vigorous exercise						0.562
No	5407 (75.78)	1797/5202	117/205	2.52 (1.90–3.34)	<0.001	
Yes	1728 (24.22)	594/1672	35/56	3.02 (1.74–5.24)	<0.001	
Moderate exercise						0.109
No	4096 (57.41)	1356/3953	89/143	3.16 (2.24–4.45)	<0.001	
Yes	3039 (42.59)	1035/2921	63/118	2.09 (1.44–3.02)	<0.001	

(*Continued*)

Table 12 (Continued).

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
Sedentary						0.741
No	991 (13.89)	368/957	22/34	2.93 (1.43–6.00)	0.003	
Yes	6144 (86.11)	2023/5917	130/227	2.58 (1.97–3.37)	<0.001	
Smoke						0.116
No	3630 (50.88)	1002/3547	46/83	3.16 (2.04–4.90)	<0.001	
Yes	3505 (49.12)	1389/3327	106/178	2.05 (1.51–2.79)	<0.001	
Prescription Medication Use						0.034
No	2987 (41.86)	731/2972	10/15	6.13 (2.09–18.00)	<0.001	
Yes	4148 (58.14)	1660/3902	142/246	1.84 (1.42–2.39)	<0.001	
Marital Status						0.661
Married	3805 (53.33)	1291/3641	89/164	2.16 (1.58–2.96)	<0.001	
Widowed	361 (5.06)	173/323	25/38	1.67 (0.82–3.37)	0.155	
Divorced	819 (11.48)	324/787	21/32	2.73 (1.30–5.74)	0.008	
Separated	278 (3.90)	90/268	7/10	4.61 (1.17–18.27)	0.029	
Never married	1283 (17.98)	316/1273	5/10	3.03 (0.87–10.53)	0.081	
Living with partner	589 (8.26)	197/582	5/7	4.89 (0.94–25.41)	0.059	

Abbreviations: OR, Odds Ratio; CI, Confidence Interval; PIR, Poverty income ratio; BMI, body mass index.

Age

For individuals under 65 years (OR = 2.63, 95% CI: 1.87–3.68, P < 0.001), the association between chronic pain and coronary heart disease is notably strong. In those 65 years and older, the relationship is still significant but weaker (OR = 1.60, 95% CI: 1.08–2.36, P = 0.019), suggesting that the association between chronic pain and coronary heart disease decreases with age.

Gender

Females exhibit a stronger relationship between chronic pain and coronary heart disease, with an OR of 3.34 (95% CI: 2.12–5.24, P < 0.001), indicating a higher risk of comorbid chronic pain in women compared to men. For males, the OR is 2.52 (95% CI: 1.85–3.42, P < 0.001), also indicating a significant association, but the risk is comparatively lower than for females.

Race

Non-Hispanic White individuals have a strong association (OR = 2.48, 95% CI: 1.81–3.42, P < 0.001), which is the highest among different racial groups. Non-Hispanic Black individuals also show a significant association (OR = 2.99, 95% CI: 1.60–5.61, P < 0.001), highlighting the elevated risk for this group. Mexican American individuals (OR = 2.02, 95% CI: 0.96–4.23, P = 0.064) and Other Race (OR = 3.30, 95% CI: 0.98–11.08, P = 0.054) show trends towards increased risk, though these results are on the border of statistical significance.

BMI

BMI 18.5–24.9 individuals have an OR of 2.31 (95% CI: 1.36–3.94, P = 0.002), showing a moderate risk of comorbidity. BMI ≥ 30 individuals (OR = 2.44, 95% CI: 1.70–3.52, P < 0.001), reflecting an increased risk associated with obesity. BMI 25.0–29.9 individuals show the highest OR (OR = 2.91, 95% CI: 1.83–4.64, P < 0.001), suggesting that overweight individuals are at the highest risk of chronic pain and coronary heart disease comorbidity.

Vigorous Exercise

For those not engaging in vigorous exercise, the OR is 2.52 (95% CI: 1.90–3.34, P < 0.001), indicating a strong association between lack of vigorous exercise and comorbid chronic pain and coronary heart disease. Engagement in

vigorous exercise was associated with a slightly higher (OR = 3.02, 95% CI: 1.74–5.24, P < 0.001), suggesting that exercise is a protective factor, although the comorbidity risk remains significant.

Prescription Medication Use

Non-users of prescription medications exhibited a significantly higher risk (OR = 6.13, 95% CI: 2.09–18.00, P = 0.011), indicating that those not using prescribed medication are at substantially higher risk for the comorbidity of chronic pain and coronary heart disease. Prescription medication users had a lower but still significant (OR = 1.84,95% CI: 1.42–2.39, P < 0.001).

Marital Status

Divorced individuals had a significantly increased risk of chronic pain and coronary heart disease comorbidity, with an OR of 2.73 (95% CI: 1.30–5.74, P = 0.008). Separated individuals had an even higher OR of 4.61 (95% CI: 1.17–18.27, P = 0.029), indicating that relationship status plays a significant role in the comorbidity.

Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Asthma

Table 13 presents the results of a subgroup analysis on the comorbid risk factors associated with chronic pain and asthma. The analysis stratified the data based on sociodemographic factors such as age, gender, race, education, and lifestyle factors including exercise, smoking, and medication use. Statistically significant results (P-value < 0.05 and confidence intervals not containing 1) are highlighted below:

Table 13 Subgroup Analysis of Comorbid Risk Factors for Chronic Pain and Asthma

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
All patients	7135 (1000.00)	2090/6080	453/1055	1.44 (1.26–1.64)	<0.001	
Age						0.067
<65	6245 (87.53)	1695/5294	400/951	1.54 (1.34–1.78)	<0.001	
≥65	890 (12.47)	395/786	53/104	1.03 (0.68–1.55)	0.892	
Gender						0.010
Female	3828 (53.65)	1137/3182	307/646	1.63 (1.37–1.93)	<0.001	
Male	3307 (46.35)	953/2898	146/409	1.13 (0.91–1.41)	0.259	
Race						<0.001
Mexican American	1296 (18.16)	332/1185	45/111	1.75 (1.17–2.61)	0.006	
Other Hispanic	562 (7.88)	97/484	30/78	2.49 (1.50–4.14)	<0.001	
Non-Hispanic White	3629 (50.86)	1239/3049	264/580	1.22 (1.02–1.46)	0.029	
Non-Hispanic Black	1311 (18.37)	354/1071	89/240	1.19 (0.89–1.60)	0.233	
Other Race	337 (4.72)	68/291	25/46	3.90 (2.06–7.41)	<0.001	
PIR						0.014
<1	1604 (22.48)	467/1314	141/290	1.72 (1.33–2.22)	<0.001	
1–3	2891 (40.52)	851/2461	195/430	1.57 (1.28–1.93)	<0.001	
>3	2640 (370.00)	772/2305	117/335	1.07 (0.84–1.36)	0.604	
Education						0.010
Less Than 9th Grade	776 (10.88)	248/703	40/73	2.22 (1.37–3.62)	0.001	
9–11th Grade	1141 (15.99)	344/947	97/194	1.75 (1.28–2.39)	<0.001	
High School Grad	1709 (23.95)	562/1464	101/245	1.13 (0.85–1.48)	0.399	
Some College degree	2076 (29.10)	607/1723	165/353	1.61 (1.28–2.03)	<0.001	
College Graduate	1433 (20.08)	329/1243	50/190	0.99 (0.70–1.40)	0.965	

(*Continued*)

Table 13 (Continued).

Variables	Event, n (%)	Chronic Pain		OR (95% CI)	*P*-value	P for Interaction
		No	Yes			
BMI						0.514
<18.5	120 (1.68)	35/101	9/19	1.70 (0.63–4.56)	0.295	
18.5–24.9	1920 (26.91)	506/1639	114/281	1.53 (1.18–1.98)	0.001	
≥30	2721 (38.14)	812/2250	217/471	1.51 (1.24–1.85)	<0.001	
25.0–29.9	2374 (33.27)	737/2090	113/284	1.21 (0.94–1.56)	0.136	
Vigorous exercise						0.682
No	5407 (75.78)	1575/4619	339/788	1.46 (1.25–1.70)	<0.001	
Yes	1728 (24.22)	515/1461	114/267	1.37 (1.05–1.78)	0.020	
Moderate exercise						0.555
No	4096 (57.41)	1192/3512	253/584	1.49 (1.25–1.78)	<0.001	
Yes	3039 (42.59)	898/2568	200/471	1.37 (1.12–1.68)	0.002	
Sedentary						0.191
No	991 (13.89)	330/849	60/142	1.15 (0.80–1.65)	0.445	
Yes	6144 (86.11)	1760/5231	393/913	1.49 (1.29–1.72)	<0.001	
Smoke						0.307
No	3630 (50.88)	899/3180	149/450	1.26 (1.02–1.55)	0.034	
Yes	3505 (49.12)	1191/2900	304/605	1.45 (1.22–1.73)	<0.001	
Prescription Medication Use						0.522
No	2987 (41.86)	651/2667	90/320	1.21 (0.94–1.57)	0.146	
Yes	4148 (58.14)	1439/3413	363/735	1.34 (1.14–1.57)	<0.001	
Marital Status						0.649
Married	3805 (53.33)	1180/3336	200/469	1.36 (1.12–1.65)	0.002	
Widowed	361 (5.06)	168/313	30/48	1.44 (0.77–2.69)	0.254	
Divorced	819 (11.48)	261/659	84/160	1.69 (1.19–2.39)	0.003	
Separated	278 (3.90)	76/233	21/45	1.81 (0.95–3.45)	0.073	
Never married	1283 (17.98)	250/1049	71/234	1.39 (1.02–1.90)	0.038	
Living with partner	589 (8.26)	155/490	47/99	1.95 (1.26–3.03)	0.003	

Abbreviations: OR, Odds Ratio; CI, Confidence Interval; PIR, Poverty income ratio; BMI, body mass index.

Age

Among those younger than 65 years, the association remains strong (OR = 1.54, 95% CI: 1.34–1.78, P < 0.001). However, those aged 65 years or older show no significant association (OR = 1.03, 95% CI: 0.68–1.55, P = 0.892), suggesting that age might modulate the impact of asthma on chronic pain risk.

Gender

Females show a significant association with chronic pain and asthma (OR = 1.63, 95% CI: 1.37–1.93, P < 0.001), highlighting a stronger link in women. Males do not show a significant relationship (OR = 1.13, 95% CI: 0.91–1.41, P = 0.259), indicating that gender might influence the association between asthma and chronic pain.

Race

Race: Mexican Americans show a significant risk (OR = 1.75, 95% CI: 1.17–2.61, P = 0.006), indicating a higher likelihood of chronic pain in this group. Other Hispanic individuals exhibit a very strong association (OR = 2.49, 95% CI: 1.50–4.14, P < 0.001), which is one of the highest among racial groups. Non-Hispanic White individuals also show significant results (OR = 1.22, 95% CI: 1.02–1.46, P = 0.029). Non-Hispanic Black individuals did not show a significant relationship (OR = 1.19, 95% CI: 0.89–1.60, P = 0.233).

BMI

BMI 18.5–24.9 (OR = 1.53, 95% CI: 1.18–1.98, P = 0.001) and BMI ≥ 30 (OR = 1.51, 95% CI: 1.24–1.85, P < 0.001) show significant associations with chronic pain in those with asthma. BMI 25.0–29.9 shows no significant association (OR = 1.21, 95% CI: 0.94–1.56, P = 0.136).

Vigorous Exercise

Non-participants in vigorous exercise show a significant association (OR = 1.46, 95% CI: 1.25–1.70, P < 0.001). Participants in vigorous exercise show a slightly weaker but still significant association (OR = 1.37, 95% CI: 1.05–1.78, P = 0.020).

Prescription Medication Use

Non-users of prescription medication did not show a significant relationship (OR = 1.21, 95% CI: 0.94–1.57, P < 0.001). Prescription medication users show a significantly lower risk (OR = 1.45, 95% CI: 1.00–1.73, P < 0.001).

Marital Status

Divorced individuals show a significant risk (OR = 1.69, 95% CI: 1.19–2.39, P = 0.003). Separated individuals also show no significant association (OR = 1.81, 95% CI: 0.95–3.45, P = 0.029). Married individuals show a significant but lower association (OR = 1.36, 95% CI: 1.12–1.65, P = 0.002).

Discussion

This study analyzed data from 7,135 adults in the NHANES database to examine the comorbid relationship between chronic pain and various chronic diseases. Unlike most existing studies that focus on the association between chronic pain and individual chronic conditions, this study is the first to provide a comprehensive analysis of the comorbidity between chronic pain and multiple chronic diseases, including arthritis, renal failure, liver disease, and congestive heart failure. This approach fills a critical gap in the integration of chronic pain into the management of chronic diseases. Our findings reveal significant comorbid associations between chronic pain and these chronic conditions, with these associations remaining significant even after adjusting for demographic characteristics, social factors, and behavioral patterns. Notably, the association with arthritis was the most pronounced (OR = 3.07, 95% CI: 2.71−3.48), aligning with existing literature. For instance, the disease activity in rheumatoid arthritis is closely linked to pain and functional impairment, and arthritis promotes chronic pain through immune response activation of glial cells.[20–22] This study further reinforces the widespread presence of chronic pain in patients with joint diseases.

Furthermore, we found that factors such as smoking, prescription medication use, and bereavement are closely associated with the occurrence of chronic pain. Smoking has been shown to activate dopamine pathways in the anterior cingulate cortex, leading to hyperalgesia.[23,24] Similarly, a 2024 epidemiological survey found that smokers have a 24% increased risk of chronic pain.[25] Regarding prescription medications, chronic pain patients may develop a dependency cycle when using pain-relieving drugs, which exacerbates their pain perception.[26,27] The association between widowed and chronic pain has been observed in epidemiological studies, although the underlying mechanisms remain unclear.[28] Future research could further investigate the potential mechanisms by which bereavement influences chronic pain.

In further subgroup analyses, we found that individuals under the age of 65 who do not engage in moderate physical activity exhibit the highest risk of chronic pain comorbidity. This result is consistent with existing literature.[29,30] Notably, in patients with diseases such as arthritis, renal failure, liver disease, and emphysema, male patients exhibited a more significant risk of chronic pain comorbidity, whereas in patients with congestive heart failure, chronic bronchitis, coronary heart disease, and asthma, female patients had a higher risk. This gender difference may be related to the distinct physiological and psychological mechanisms underlying pain experience and treatment responses between genders. Therefore, future research should explore the role of gender differences in the comorbidity between chronic pain and chronic diseases.

Additionally, smokers with renal failure, liver disease, and emphysema exhibited a significantly higher risk of chronic pain comorbidity, which aligns with the negative effects of smoking on inflammation and pain perception.[31–33] We also found that patients with arthritis, renal failure, and liver disease who did not use prescription medications had a higher

risk of chronic pain comorbidity, potentially due to inadequate pain control in the chronic management of these diseases. For example, patients with chronic kidney disease, especially in its later stages, are generally advised against the routine use of nonsteroidal anti-inflammatory drugs (NSAIDs) for pain relief, as these medications can inhibit prostaglandin production and exacerbate kidney function deterioration.[34]

Although diabetes is known to be a risk factor for chronic pain, we were unable to find a significant association between diabetes and chronic pain in this study.[35,36] We speculate that this may be due to better disease control in diabetic patients, particularly those with a shorter disease duration or those well-managed, who may not exhibit significant neuropathic pain. Additionally, the study did not differentiate between types of chronic pain, such as neuropathic pain and musculoskeletal pain, which may have contributed to the lack of observed association with diabetes-related pain. Future research should consider including pain type as a factor to more accurately assess the impact of diabetes on chronic pain.

Overall, the innovation of this study lies in its comprehensive analysis of the relationship between chronic pain and multiple chronic diseases, rather than focusing solely on a single disease. This holistic approach offers a new perspective for managing chronic diseases, emphasizing the need to integrate chronic pain into the comprehensive management of these conditions. Particularly in early diagnosis and treatment, it is essential to consider the patient's chronic pain status and its potential impact on the progression of chronic diseases. As the population of chronic disease patients continues to grow, future clinical efforts should focus more on the early recognition and intervention of chronic pain.

Finally, although this study provides valuable insights into the comorbidity between chronic pain and chronic diseases, several limitations must be acknowledged. First, the study used a cross-sectional design, which limits causal inference. Longitudinal studies are needed to better understand the causal relationship between chronic pain and chronic diseases. Second, while we controlled for multiple covariates, factors such as mental health (eg, anxiety, depression) and medication history, were not fully incorporated into the analysis due to data limitations. Future studies should consider these factors. Lastly, although the NHANES dataset is highly representative, reliance on self-reported diagnoses may introduce information bias. Future research could combine biomarker data and other objective measures to reduce this bias.

Conclusions

This study is the first to comprehensively analyze the relationship between chronic pain and multiple chronic diseases, revealing significant comorbid associations between chronic pain and various conditions, including arthritis, renal failure, and liver disease. Notably, the strongest association was observed with arthritis, supporting the widespread occurrence of chronic pain in patients with joint diseases. Additionally, social and behavioral factors such as smoking, prescription medication use, and bereavement were found to significantly influence the occurrence of chronic pain.

The findings emphasize that chronic pain should be integrated into the comprehensive management of chronic diseases, particularly during early diagnosis and treatment. Future studies should adopt longitudinal designs to further explore the causal relationship between chronic pain and chronic diseases and take into account pain type and the management of conditions such as diabetes.

Abbreviations

BMI, body mass index; PIR, poverty income ratio; CDC, Centers for Disease Control and Prevention; NHANES, National Health and Nutrition Examination Survey; SD, standard deviation.

Ethics Approval and Informed Consent

This study utilized de-identified, publicly available data from the National Health and Nutrition Examination Survey (NHANES) database. According to the Measures for Ethical Review of Life Science and Medical Research Involving Human Subjects (issued by the National Health Commission of China et al on February 18, 2023), research involving the use of such publicly available informational data is exempt from ethical review. Therefore, no separate ethics committee approval was required for this analysis. The original NHANES protocols were reviewed and approved by the National Center for Health Statistics (NCHS) Ethics Review Board, and all participants provided informed consent. NHANES data collection complies with strict US federal confidentiality laws, including Section 308(d) of the Public Health Service Act.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

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