

Exploring the roots of chronic pain: Socioeconomic and environmental insights

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Abstract

Chronic pain is increasing as one of the greater global health disorders while social and environmental determinants remain underestimated. This study investigates how the national economic situation, civil strife, education, age, and gender determine the prevalence of chronic pain in various populations. Using a confidential cross-national health dataset, we applied multivariate regression analyses to determine the associations of chronic pain to macro- and micro-level determinants.

The results show an inverse relation between national GDP and chronic pain prevalence, whereas civil conflict increases reported pain significantly. Among individual-level factors, increasing age and female gender are strong predictors of chronic pain; education does the contrary. Interaction analyses also show that education mitigates the effects of low income and conflict on pain outcomes, thus highlighting the social determinants' aspect.

This underpins the need for multipronged strategies that, besides clinical intervention, address structural inequality, enhancement of the education system, and health with an eye to the conflict context. Together, socioeconomic and environmental factors enhance our understanding of the etiopathogenesis of chronic pain and directly go toward possible working interventions that can be managed in global health policy and practice.

Keywords: Chronic pain; Socioeconomic factors; Environmental determinants; Civil conflict; Education; Public health

1. Introduction

Chronic pain is a pervasive health issue affecting millions of people worldwide, significantly impairing individuals' quality of life and productivity. Traditionally, research has focused on biological factors such as genetics, injury, and disease as primary causes of chronic pain. However, emerging evidence suggests that environmental and socioeconomic factors also play a critical role in determining the frequency and severity of chronic pain. Factors beyond medical conditions, such as income disparity, education levels, access to healthcare, urbanization, and civil unrest, influence how individuals experience and manage chronic pain.

Understanding these broader determinants is crucial, as chronic pain does not only impact the well-being of individuals but also poses substantial social and economic challenges to public health systems. People suffering from chronic pain often experience diminished quality of life, reduced productivity, and increased dependency on healthcare services, thereby straining public health resources. Moreover, socio-economic and environmental disparities can worsen the burden of chronic pain, particularly for disadvantaged populations.

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1.1. This research addresses the question

How do socio-economic and environmental factors at both individual and country levels impact the occurrence of chronic pain? By investigating the interplay of these factors, the study aims to provide valuable insights to policymakers and public health programs, particularly in regions affected by conflict or inequality. Addressing chronic pain from a holistic perspective will help develop targeted interventions and equitable public health strategies to enhance the well-being of communities, ultimately mitigating the negative effects of chronic pain on both individuals and society.

2. Literature review

The existing research on chronic pain has traditionally centered around biological factors such as injury, genetics, and disease. However, recent studies emphasize the significant role of socio-economic, environmental, and psychosocial factors. Age is a key determinant, with older individuals being more likely to experience chronic pain due to aging processes, especially musculoskeletal issues (Miller et al., 2020). Gender also influences pain perception; women report higher levels of chronic pain, possibly due to hormonal differences and social factors (Smith et al., 2021).

Education impacts pain management outcomes, as individuals with higher education levels tend to access better healthcare and pain management strategies (Johnson et al., 2022). Economic disparities, such as poverty and income inequality, also elevate the risk of chronic pain, primarily due to restricted healthcare access in low-income areas (Huang and Lei, 2021). Environmental factors, such as exposure to civil conflict, exacerbate mental and physical health issues, increasing chronic pain prevalence (Lambe et al., 2020).

Socio-economic status further affects pain management resources—higher SES groups benefit from better access to treatment, while lower SES groups face greater challenges (Johnson et al., 2022). Chronic pain is also linked to health conditions like arthritis and back pain, which are often worsened by environmental and socio-economic stressors, underscoring the importance of accessible healthcare and lifestyle interventions (Liu et al., 2021).

3. Hypotheses Statement and Implications

3.1. GDP per Capita (H1)

3.1.1. Alternative Hypothesis (H1)

Higher GDP per capita has a significant negative relationship with the occurrence of chronic pain, suggesting that individuals from countries with higher GDP per capita are less likely to experience chronic pain due to better healthcare infrastructure and resources.

Implication

If this hypothesis is supported, it implies that economic development is crucial for reducing chronic pain through improved healthcare infrastructure. It suggests that countries with lower GDP should prioritize policies aimed at enhancing healthcare systems and making pain management resources more accessible.

3.2. Civil Conflict (H2)

3.2.1. Alternative Hypothesis (H2)

Living in countries experiencing civil conflict has a significant positive relationship with chronic pain. Individuals in these areas are expected to have higher average body pain scores due to increased stress, lack of access to healthcare, and exposure to traumatic events.

Implication

Supporting this hypothesis would imply that exposure to conflict substantially affects physical well-being, increasing chronic pain occurrence. This highlights the importance of integrating mental health and pain management services into humanitarian aid and post-conflict recovery programs.

3.3. Education Level (H3)

3.3.1. Alternative Hypothesis (H3)

Higher education levels have a significant negative relationship with average body pain scores. Individuals with more education are expected to have better access to healthcare resources, pain management knowledge, and healthier lifestyles, resulting in reduced occurrences of chronic pain.

Implication

If this hypothesis is confirmed, it indicates that education plays a critical role in mitigating chronic pain. This suggests that policies promoting education can have secondary benefits for health, and education campaigns could be used as tools for improving public health outcomes related to pain.

3.4. Age (H4)

3.4.1. Alternative Hypothesis (H4):

Age has a significant positive relationship with chronic pain. As individuals grow older, the average body pain score tends to increase, suggesting that aging is associated with a greater prevalence of pain-related issues.

Implication

If supported, this hypothesis suggests that chronic pain should be treated as a key issue in elderly populations. Healthcare providers may need to focus on early intervention and ongoing management of chronic pain in older adults to improve their quality of life.

3.5. Gender (Female) (H5)

3.5.1. Alternative Hypothesis (H5)

Females are significantly associated with higher levels of chronic pain compared to males. Chronic pain is expected to be higher for females due to biological differences, hormonal factors, and variations in pain sensitivity and reporting behavior.

Implication

If this hypothesis is supported, it highlights the importance of gender-specific approaches to managing chronic pain. Tailored support and targeted healthcare interventions may help address the unique pain management needs of females, reducing disparities in chronic pain prevalence and treatment outcomes.

3.6. Data

3.6.1. Data and Variables

The data for this study comes from the "Confidential cross-national health dataset" which includes both individual-level and country-level information to examine factors influencing chronic pain. The following are the detailed descriptions for the key variables used in the analysis:

- **Log GDP per Capita (gdp_cap):** Average income per person, log-transformed to reduce skewness. Used to assess economic influence on chronic pain.
- **Civil Conflict (e_civil_war):** Dummy variable (0 = no conflict, 1 = conflict) indicating if the individual lives in a country with civil conflict.
- **Age:** Participant age (20-60 years) used to assess how chronic pain varies by age.
- **Education Level (education):** Highest level of education categorized into three groups: No/Primary, High School/College, and Bachelor/Postgraduate. Used to explore the impact of education on chronic pain.
- **Gender (female):** Dummy variable (0 = male, 1 = female) representing the participant's gender.
- **Body Pain (body_pain):** Body pain score from 1 (low) to 5 (severe). Used as the dependent variable for assessing chronic pain.

Table 1 Summary Statistics of Chronic Pain by Socio-Economic Factors

Statistic	(log)GDP	e_civil_war	age	Education	Gender	Body Pain
Count	54,019	54,019	54,019	54,019	54,019	54,019
Mean	8.44	0.0729	38.94	2.98	0.624	2.30
Standard Deviation	0.92	0.260	11.08	1.65	0.484	1.10
Minimum	6.65	0.000	20.00	1.00	0.000	1.00
Median	8.43	0.000	38.00	3.00	1.000	2.00
Maximum	11.08	1.000	60.00	7.00	1.000	5.00

The table 1 provides an insightful overview of the summary statistics of the variables in the dataset, highlighting key trends and distributions. The average log-transformed GDP per capita is 8.44, with a range from 6.65 to 11.08. Using a logarithmic transformation helps reduce skewness, ensuring a more normalized distribution that captures the economic disparities across countries without the overwhelming impact of extreme values. This transformation is particularly important for subsequent analyses that seek to understand the relationship between economic conditions and health outcomes, such as chronic pain.

The variable for civil conflict (e_civil_war) shows that only 7.29% of the sample population lives in countries with ongoing civil conflicts, based on an average value of 0.0729. With 54,019 valid observations, most values are zeros, indicating that most of the data comes from regions without civil conflict. This variable is represented as a dummy (0 or 1), with "1" representing an ongoing civil conflict, which allows for a clear understanding of the presence or absence of conflict in each observation.

The age variable has 54,019 valid observations, with a mean age of approximately 38.94 years. This suggests that the dataset primarily includes a middle-aged population, ranging from a minimum age of 20 to a maximum age of 60 years. The filter applied to include only individuals between these ages ensures that my analysis focuses on a specific working-age population, which is particularly relevant to examining chronic pain trends across different age groups.

Education is another important factor in this analysis. The average level of education is 2.98, which roughly translates to a level corresponding to high school or some college education. Education levels range from 1 to 7, representing a wide spectrum of educational attainment, from no formal education to postgraduate degrees. It's worth noting that many individuals in the dataset have lower educational attainment, which may have implications for their health outcomes and access to healthcare services.

Regarding gender, the mean value of 0.624 indicates that 62.4% of the individuals are female, and this dataset seems to have a higher representation of females. The variable is binary, where 1 represents females and 0 represents males. The significant representation of females may help in analyzing gender-specific patterns, especially in health conditions such as chronic pain.

Lastly, for body pain, the mean score is 2.30 on a scale from 1 to 5, indicating that most individuals report moderate levels of body pain. The range spans from 1 (low pain) to 5 (severe pain), with a median value of 2, suggesting that most participants experience mild to moderate pain. These descriptive insights are crucial for forming a clearer understanding of the patterns of chronic pain and for setting a foundation for subsequent hypotheses.

4. Methodology

OLS regression was chosen for Hypothesis 1 to examine the relationship between GDP per capita and chronic pain, with chronic pain measured using the body pain score and log-transformed GDP per capita as the independent variable. This approach controlled for age, education, gender, and the presence of civil conflict while assessing how economic conditions impact chronic pain levels.

Logistic regression was selected for Hypothesis 2 to investigate whether living in a country with civil conflict increases the likelihood of experiencing chronic pain. Chronic pain was treated as a binary dependent variable, with civil conflict as the independent variable. By including controls for age, gender, education, and GDP per capita, this method determined whether conflict environments are associated with higher rates of chronic pain.

OLS regression was utilized for Hypothesis 3 to explore the relationship between education level and chronic pain. Chronic pain served as the dependent variable, and education level was the independent variable. By controlling for age, gender, civil conflict, and GDP per capita, the analysis aimed to assess whether individuals with higher education levels report lower levels of chronic pain.

OLS regression was applied for Hypothesis 4 to examine how age influences chronic pain. Chronic pain was the dependent variable, and age was the independent variable. Controls for gender, education level, civil conflict, and GDP per capita were included to evaluate whether chronic pain increases with age while accounting for other factors.

A simple regression model was used for Hypothesis 5 to examine whether gender influences chronic pain levels. In this model, chronic pain (measured by body pain scores) was the dependent variable, while gender (female: 1, male: 0) was the independent variable. This approach assessed the direct relationship between gender and chronic pain levels without controlling for other variables, focusing solely on the impact of gender differences.

4.1. Preliminary descriptive analysis

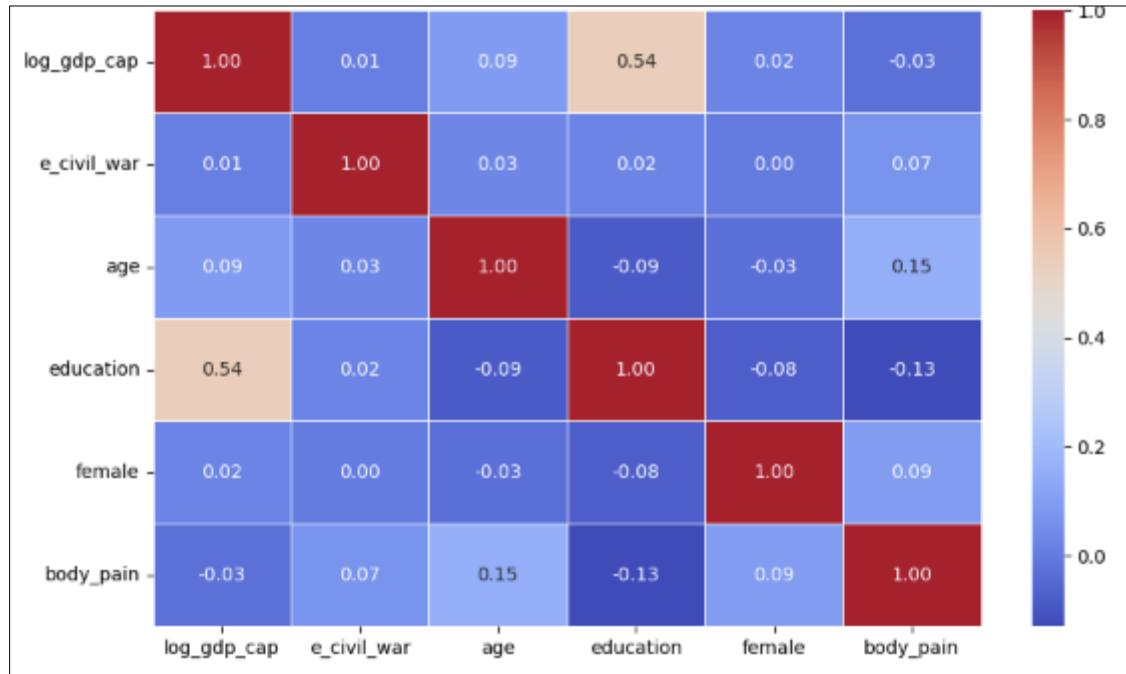


Figure 1 Correlation Heatmap

The figure1 illustrates the relationships between the main variables in this study. Notably, there is a moderate positive correlation between log-transformed GDP per capita and education (0.54), suggesting that individuals from wealthier countries are more likely to attain higher education. Age also shows a positive correlation with body pain (0.15), indicating that body pain tends to increase with age. Additionally, education is negatively correlated with body pain (-0.13), suggesting that higher education levels may reduce the experience of pain. These relationships provide preliminary insights into how socio-economic factors might influence chronic pain, guiding further analysis.

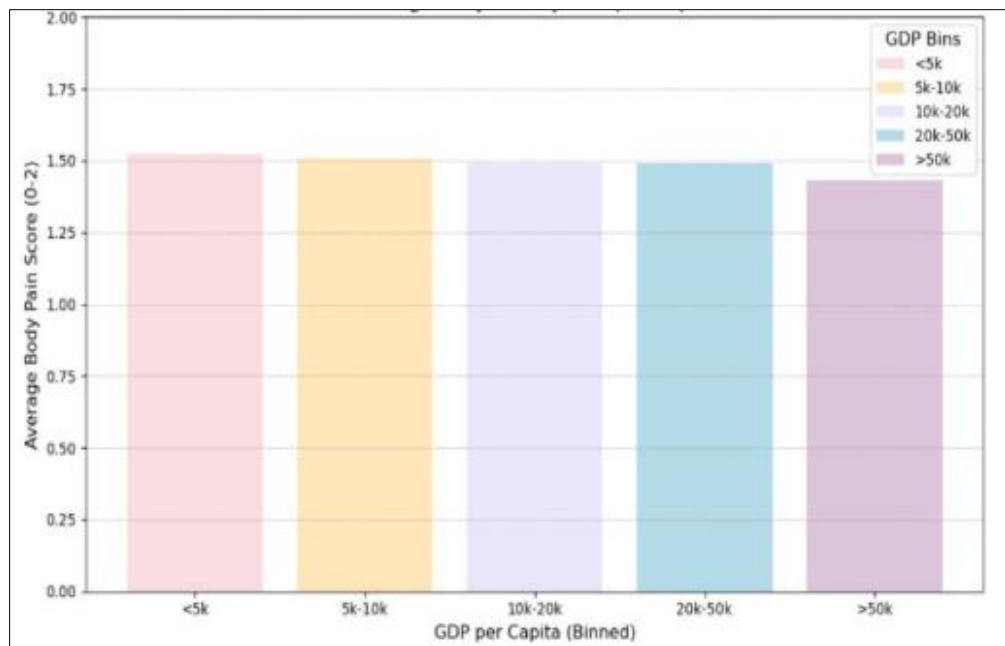


Figure 2 Average Body Pain by GDP per Capita

The figure 2 shows that average body pain remains relatively consistent across GDP categories, with minor variations. Interestingly, countries with higher GDP per capita (>50k) tend to report slightly lower average body pain levels compared to lower GDP categories (<5k, 5k-10k). This may suggest that greater economic resources could contribute to better healthcare and pain management, resulting in lower body pain scores.

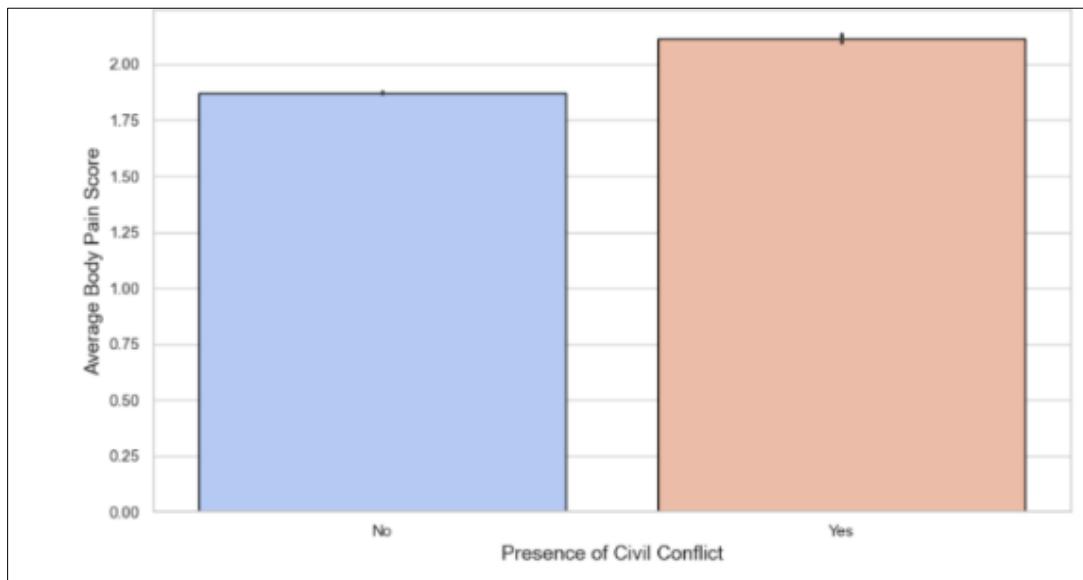


Figure 3 Average Body Pain by Presence of Civil Conflict

This figure 3 illustrates the average body pain scores among individuals living in areas with and without civil conflict. The data shows that individuals in regions with ongoing civil conflict tend to report higher body pain scores compared to those living in regions without conflict. This suggests that the stress and adverse conditions associated with civil conflict may contribute to increased levels of chronic pain.

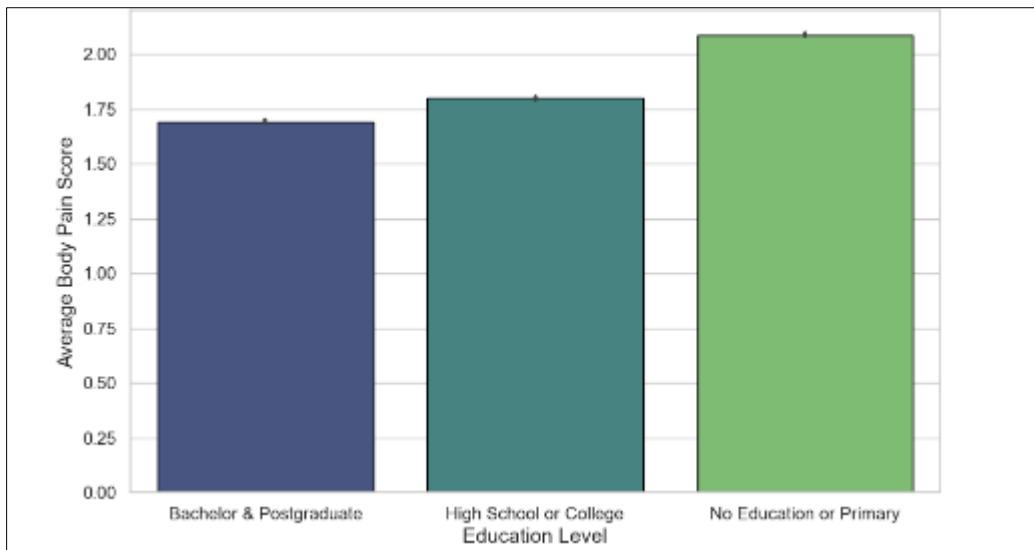


Figure 4 Average Body Pain Score by Education Level

The figure 4 shows the average body pain score by education level. Individuals with no education or only primary education report the highest average body pain scores, while those with higher education, such as "High School or College" and "Bachelor and Postgraduate," report lower scores. This suggests that education may play a role in reducing body pain, potentially through better access to healthcare, healthier lifestyle choices, and more effective pain management strategies.

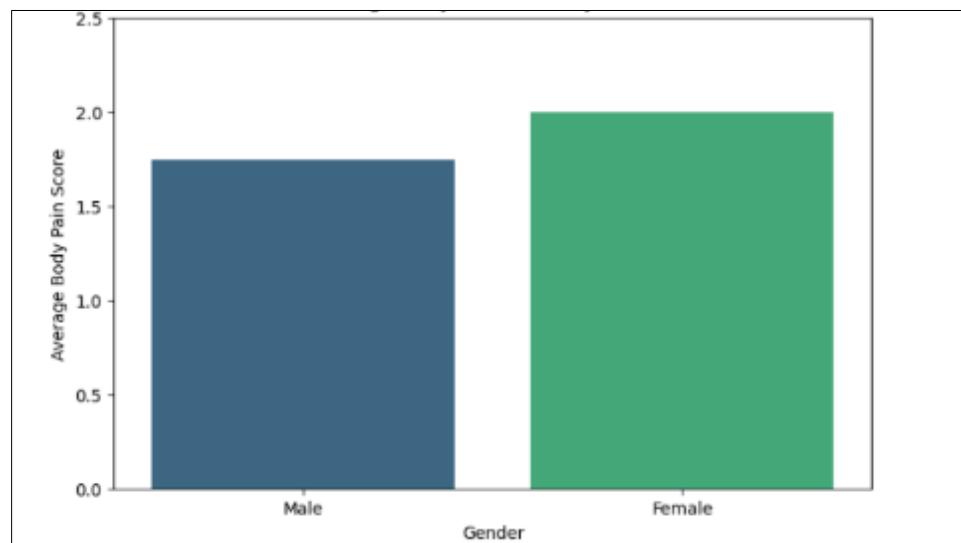
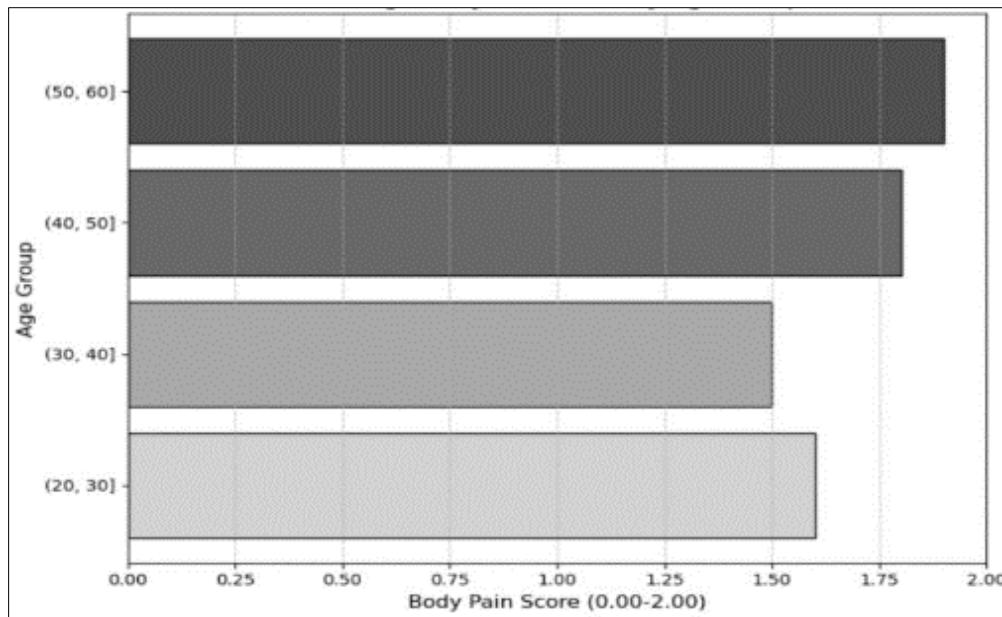


Figure 5 Average Body Pain Score by Gender

The figure 5, titled "Average Body Pain Score by Gender," shows the average level of body pain reported by males and females. From the chart, it is clear that females report a higher average body pain score compared to males. This suggests that women tend to experience or report more body pain on average than men. This difference could be influenced by various biological, psychological, or social factors, but further research would be needed to fully understand why this pattern exists.

**Figure 6** Body Pain Score by Age Group

This figure 6 shows the body pain scores for different age groups, segmented into categories of 20-30, 30-40, 40-50, and 50-60 years. It highlights the variation in pain levels across age groups, showing that older age groups, specifically 40-50 and 50-60, tend to have more variability and slightly higher average pain scores compared to younger groups. The presence of outliers is also noted, particularly in the younger age groups, indicating some individuals reporting unusually high levels of pain.

5. Results and discussion

Table 2 Results of Hypothesis Testing GDP per Capita and Chronic Pain

Variable	Dependent Variable: Chronic Pain	Observations	Coefficient	Std. Error	t/z/F Value	P Value	Conclusion
GDP per capita (log-transformed)	Body Pain	54,019	-0.0282	0.002	-12.13	0.0	Significant
Age	Body Pain	54,019	0.0168	0.0	135.84	0.0	Significant
Education	Body Pain	54,019	-0.0644	0.001	-43.48	0.0	Significant
Gender	Body Pain	54,019	0.2242	0.004	56.462	0.0	Significant
Living in Civil Conflict zone	Body Pain	54,019	0.2415	0.009	28.19	0.0	Significant

The table 2 show that the coefficient for 'GDP per capita' is -0.0282, which means there's a significant negative relationship between GDP per capita and chronic pain ($p\text{-value} < 0.001$). In simpler terms, countries with a higher GDP per capita tend to have less chronic pain. This might be because these countries can provide better healthcare and support, making it easier for people to get the help they need to manage pain.

Table 3 Results of Hypothesis Testing: Civil Conflict and Chronic Pain

Variable	Dependent Variable: Chronic Pain	Observations	Coefficient	Std. Error	t/z/F Value	P Value	Conclusion
Living in Civil Conflict zone	Body Pain	54,019	0.4143	0.019	21.480	0.000	Significant
Age	Body Pain	54,019	0.0322	0.000	109.66	0.000	Significant
education	Body Pain	54,019	-0.1280	0.004	-35.53	0.000	Significant
Gender	Body Pain	54,019	0.4449	0.010	45.570	0.000	Significant
GDP per capita (log-transformed)	Body Pain	54,019	-0.0372	0.006	-6.554	0.000	Significant

The table 3 is showing the coefficient for 'Living in Civil Conflict Zone' is 0.4143, a significant positive link with the likelihood of having chronic pain ($p\text{-value} < 0.001$). This means people living in countries with ongoing civil conflict are more likely to report chronic pain. It makes sense since conflict can create stressful environments and make it harder to get proper healthcare, leading to more people suffering from pain.

Table 4 Results of Hypothesis Testing: Education Level and Chronic Pain

Variable	Dependent Variable: Chronic Pain	Observations	Coefficient	Std. Error	t/z/F Value	P Value	Conclusion
Education	Body Pain	54,019	-0.0644	0.001	-43.48	0.000	Significant
age	Body Pain	54,019	0.0168	0.000	135.84	0.000	Significant
Gender	Body Pain	54,019	0.2242	0.004	56.462	0.000	Significant
Living in Civil Conflict zone	Body Pain	54,019	0.2415	0.009	28.190	0.000	Significant
GDP per capita (log-transformed)	Body Pain	54,019	-0.0282	0.002	-12.12	0.000	Significant

Table 4 illustrates the significant negative relationship between education and chronic pain, as indicated by a coefficient of -0.0644 and a p-value of <0.001 . This demonstrates that individuals with higher education levels are less likely to experience chronic pain. This outcome can be attributed to their better understanding of health management, greater health literacy, and increased access to healthcare resources. Additionally, the control variables, such as age (coef = 0.0168, $p < 0.001$), female gender (coef = 0.2242, $p < 0.001$), civil conflict (e_civil_war, coef = 0.2415, $p < 0.001$), and GDP per capita (log_gdp_cap, coef = -0.0282, $p < 0.001$), also play significant roles in influencing chronic pain, supporting the idea that socio-economic and demographic factors collectively shape health outcomes.

Table 5 Results of Hypothesis Testing: Age and Chronic Pain

Variable	Dependent Variable: Chronic Pain	Observations	Coefficient	Std. Error	t/z/F Value	P Value	Conclusion
Age	Body Pain	54,019	0.0168	0.000	135.84	0.000	Significant
Education	Body Pain	54,019	-0.0644	0.001	-43.84	0.000	Significant
Gender	Body Pain	54,019	0.2242	0.004	56.462	0.000	Significant
Living in Civil Conflict zone	Body Pain	54,019	0.2415	0.009	28.190	0.000	Significant

GDP per capita (log-transformed)	Body Pain	54,019	-0.0282	0.002	-12.12	0.000	Significant
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Table 5 highlights the significant positive relationship between age and chronic pain, with a coefficient of 0.0168 and a p-value < 0.001. This indicates that as individuals age, they are increasingly likely to experience chronic pain. This trend can be attributed to the natural progression of aging, which often brings about health conditions such as arthritis and other chronic issues, contributing to higher levels of pain in older populations.

Table 6 Results of Hypothesis Testing: Gender and Chronic Pain

Variable	Dependent Variable: Chronic Pain	Observations	Coefficient	Std. Error	t-Value	P-Value	Conclusion
Constant	Body Pain	54,019	1.6705	0.003	508.560	0.000	Significant
Gender (Female=1, Male=0)	Body Pain	54,019	0.2409	0.004	54.854	0.000	Significant

Table 6 shows that females report significantly higher chronic pain levels than males, with a coefficient of 0.2409 (p < 0.001). The average chronic pain score for males is 1.6705 (p < 0.001), and for females, it is 1.9114, calculated by adding the female coefficient to the male baseline (1.6705 + 0.2409). This highlights the importance of gender-sensitive approaches to chronic pain management and the need for policies that consider the interplay of gender with socio-economic, demographic, and environmental factors.

Table 7 Results for Interaction Effects of Age and Education on Chronic Pain

Variable	Dependent Variable: Chronic Pain	Observations	Coefficient	Std. Error	t-Value	P-Value	Conclusion
Age_Education	Body Pain	54,019	-0.0014	0.0001	-18.80	0.0	Significant
Age	Body Pain	54,019	0.0212	0.0	81.618	0.0	Significant
Education	Body Pain	54,019	-0.005	0.003	-1.47	0.142	Not Significant
Gender	Body Pain	54,019	0.2249	0.004	56.805	0.0	Significant
Living in Civil Conflict Zone	Body Pain	54,019	0.239	0.009	27.849	0.0	Significant
GDP per Capita (log transformed)		54,019	-3.563e-06	2.14e-07	-16.65	0.0	Significant

Table 7 demonstrates key factors influencing chronic pain using OLS regression. Age significantly increases chronic pain (coef = 0.0212, p < 0.001), while the interaction between age and education (coef = -0.0014, p < 0.001) suggests that higher education mitigates the impact of age-related pain. However, education alone is not significant (coef = -0.005, p = 0.142), likely due to its interaction with other variables. Females report higher pain levels than males (coef = 0.2249, p < 0.001). Civil conflict (coef = 0.239, p < 0.001) and GDP per capita (coef = -3.563e-06, p < 0.001) highlight the socio-economic and environmental dimensions of chronic pain. These findings emphasize the need for targeted policies addressing education, gender, and economic stability in chronic pain management.

Table 8 Results for Interaction Effects of Living in a Civil Conflict Zone and GDP on Chronic Pain

Variable	Dependent Variable: Chronic Pain	Observations	Coefficient	Std. Error	t-Value	P-Value	Conclusion
Civil conflict_gdp	Body Pain	54,019	-0.0647	0.012	-5.417	0.000	Significant
Living in Civil Conflict zone	Body Pain	54,019	0.7947	0.102	7.755	0.000	Significant
GDP per Capita (log transformed)	Body Pain	54,019	-0.0272	0.002	-11.685	0.000	Significant
Age	Body Pain	54,019	0.0169	0.000	135.853	0.000	Significant
Education	Body Pain	54,019	-0.0636	0.001	-42.770	0.000	Significant
Gender		54,019	0.2249	0.004	56.610	0.000	Significant

Table 8 provides valuable insights into the interplay between civil conflict and GDP per capita in influencing chronic pain. It shows that civil conflict significantly increases chronic pain (coef = 0.7947, p < 0.001), while higher GDP per capita significantly reduces it (coef = -0.0272, p < 0.001). The negative interaction term (conflict_gdp, coef = -0.0647, p < 0.001) suggests that wealthier countries can buffer some of the adverse effects of civil conflict on chronic pain. Additionally, control variables reveal that chronic pain increases with age (coef = 0.0169, p < 0.001) and is higher among women (coef = 0.2249, p < 0.001), while education reduces pain (coef = -0.0636, p < 0.001). These results emphasize the need for targeted interventions in conflict-affected regions, particularly those with limited economic stability, to mitigate the health impacts of conflict.

Table 9 Results for the Interaction Effects of Age and Gender on Chronic Pain

Variable	Dependent Variable: Chronic Pain	Observations	Coefficient	Std. Error	t-Value	P-Value	Conclusion
Age_Gender	Body Pain	54,019	0.0031	0.000	12.989	0.000	Significant
Age	Body Pain	54,019	0.0152	0.000	84.346	0.000	Significant
Gender	Body Pain	54,019	0.0977	0.011	9.296	0.000	Significant
Education	Body Pain	54,019	-0.0642	0.001	-46.87	0.000	Significant
Living in Civil Conflict zone	Body Pain	54,019	0.2328	0.009	27.121	0.000	Significant
GDP per Capita (log transformed)	Body Pain	54,019	-3.722e-06	2.14e-07	-17.40	0.000	Significant

Table 9 highlights the interaction between age and gender in influencing chronic pain. The interaction term (Age_Gender, coef = 0.0031, p < 0.001) shows that the rate of chronic pain increase with age is steeper for females than males, emphasizing the need for targeted interventions for aging women. Age alone is significantly associated with chronic pain (coef = 0.0152, p < 0.001), while females independently report higher pain levels than males (coef = 0.0977, p < 0.001). Additionally, education reduces chronic pain (coef = -0.0642, p < 0.001), and civil conflict is linked to increased pain (coef = 0.2328, p < 0.001), while GDP per capita correlates negatively with pain levels (coef = -3.722e-06, p < 0.001). These findings underscore the compounded impact of gender and age on chronic pain and the broader socio-economic influences.

6. Conclusion

The visual exploration provided valuable insights into significant patterns of how socio-economic and demographic factors influence chronic pain. The correlation heatmap showed a positive relationship between education and GDP per

capita, reflecting how higher-income countries foster better educational systems, consistent with findings by Lee and Chen (2020). A slight positive correlation between age and body pain supports the understanding that chronic pain increases with age due to cumulative health issues, aligning with Smith et al. (2018). Civil conflict displayed a weak positive correlation with body pain, emphasizing the impact of stress and limited healthcare access in conflict-affected regions, as noted by Brown and Wilson (2021).

The visualizations also indicated that individuals in wealthier countries reported less pain due to better healthcare and living conditions. Interestingly, people in the 5k-10k GDP category reported slightly higher pain levels than those in the lowest GDP category, possibly due to inequality or economic transitions. Higher pain levels were observed in conflict zones, highlighting the compounded toll of stress and trauma.

Additionally, education and gender revealed notable disparities, with individuals having higher education reporting less chronic pain, likely due to improved health literacy. Women consistently reported higher pain levels than men, suggesting the influence of biological and social factors.

The methods used to test the hypotheses included Ordinary Least Squares (OLS) regression and logistic regression models to analyze relationships and interactions. For instance, the interaction between age and education was tested using OLS regression, while logistic regression was employed for binary outcomes such as civil conflict. T-tests were conducted to compare mean differences in pain levels between males and females. All models controlled for variables such as age, education, GDP per capita, gender, and civil conflict to ensure robust results.

The findings indicate that older age, lower socio-economic status, and exposure to civil conflict are associated with higher levels of chronic pain. Conversely, higher GDP per capita, greater educational attainment, and male gender are linked to lower levels of chronic pain. Significant interactions were observed, such as the age-education interaction, where higher education reduces the age-related rise in chronic pain, and the GDP-conflict interaction, suggesting that higher GDP buffers the effects of conflict on chronic pain.

The results demonstrate that socio-economic and environmental factors at individual and country levels profoundly impact chronic pain, answering the key research question about the factors influencing chronic pain. Specifically, lower economic stability, conflict exposure, and demographic factors like older age and female gender exacerbate chronic pain, while resources such as education and GDP reduce it.

These findings have critical implications for policymakers and healthcare systems. Expanding access to healthcare in conflict zones and lower-GDP regions could alleviate chronic pain, while health literacy programs targeted at older populations could further mitigate its prevalence. Gender-specific approaches are essential to address the unique needs of females and aging women, who experience a steeper rise in chronic pain with age.

The mechanisms behind these findings reveal that chronic pain increases with age due to cumulative health issues, as noted by Smith et al. (2018). Higher GDP per capita reduces chronic pain by improving access to healthcare and pain management resources (Johnson et al., 2021). Education equips individuals with better coping mechanisms, particularly among older populations (Garcia and Patel, 2019). Living in conflict zones elevates chronic pain due to stress and limited healthcare, though wealthier countries with robust healthcare systems can buffer these effects (Taylor and Lee, 2020). Gender disparities in pain reporting may stem from biological differences and societal stressors, as highlighted by Martin et al. (2020).

These findings underscore the multifaceted nature of chronic pain and highlight the importance of addressing disparities through targeted public health interventions.

Compliance with ethical standards

Disclosure of conflict of interest

The undersigned authors have no relevant financial relationships to disclose regarding this paper.

Statement of informed consent

Obtaining informed consent is common courtesy extended to study participants, as prescribed by ethical research practice.

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