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Depression, Cognition, and Pain: Exploring Individual, Cultural and Country-Level Effects Across Europe

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Abstract: **The aim of this paper was to investigate the role of economic (eg, GDP per capita), political (eg, healthcare spending), cultural (country-level aggregates norms) and individual correlates (eg, depression) of pain in a secondary analysis of a sample of 76,000 adults in 19 countries across Europe. The sample was aggregated from 2 waves of the Study of Health, Ageing and Retirement in Europe cohort, using multilevel models with cross-level interactions between individual and country-level effects. While there has been extensive focus on individual risk factors (eg, depression, cognition, BMI), the role of social, political and cultural contextual factors has been relatively underexplored. In addition to replicating well-established individual risk factors (eg, increased depression), we demonstrate that higher levels of depression, chronic pain diagnosis, and collectivism, aggregated at the country-level, are also associated with increased pain severity. There was evidence that these country-level effects moderate the effect of individual correlates of pain. These results contribute to the literature by identifying the importance of broader cultural factors alongside individual psychological indices of pain reporting.**

Perspective: **In this study we model how individual, political and cultural factors influence pain in a large cross-national sample. In addition to replicating established individual effects, it shows how cultural (ie, collectivism) and political (eg, GDP, healthcare spending) factors affect individual expressions of pain, and how the cultural and individual factors interact with each other.**

Key words: *Pain, cross-country variation, arthritis, policy, cognitive function.*

Pain is universally experienced[21] with 3 broad adaptive functions to detect (identify the site of pain), protect (initiate strategies to ameliorate pain), and connect us with other people.[7,49,66] It is well established that pain captures attention and interferes with other cognitive processes when experienced.[25] Then, when experienced, people take measures to stop pain or prevent it from reoccurring.[37] Although pain affects the individual, the behaviors themselves can be perceived by other people, which may direct them to offer help.[27] While pain has social and cultural consequences,[7,66] and varies between the populations of countries,[17,18] our understanding of pain perception still focuses on the individual. This paper extends the focus on pain perception to explore geographic variation in pain and examine how cultural, economic, and political factors influence the experience of pain alongside established individual risk factors in a sample of over 76,000 respondents from 19 European countries.

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Individual Risk Factors of Pain

Given the replication crisis in behavioral science,[52] we aim to replicate cross-culturally the effects of 7 well established individual risk factors of pain severity: 1) older age, 2) being female, 3) having spent less time in education, 4) higher levels of depression, 5) a higher

Table 1. **Predictors Included in the Model, and Putative Mechanisms that Maintain Pain**

Predictor	Mechanism	Supporting Reference
Arthritis diagnosis	Chronic condition characterized by inflammation and pain in joints	41
Depression	Central sensitization modulating pain experience	2, 39, 45
Cognitive function	Bidirectional association—pain impairs cognitive function performance, but also somatoform and coping difficulties that exacerbate pain	30, 39
Age	Frailty, increased incidence of comorbid conditions	72
Education	Occupational hazards, health literacy, or indirectly through processes similar to cognitive function and socioeconomic status	30, 58
BMI	Comorbid with chronic pain, common mediating factors (eg, disordered mood and sleep)	4, 35
Sex	May be indirect (ie, through increased anxiety/depressive severity, risk of MSK conditions), or direct (eg, differential display of neurotransmitters associated with pain)	60
GDP, doctors, nurses, healthcare spending	Availability of resources in general (GDP), and specifically in the healthcare sector	18, 19
Individualism-collectivism	Wealth, display of negative emotions and coping	43

BMI, 6) a diagnosis of arthritis and 7) reduced cognitive function.[4,6,22,29,34,41,44,46–48,72] Our selection of risk factors from the SHARE dataset was designed to capture a breadth of biological, affective and social differences that may explain variation in pain.[30]

There is a considerable experimental and population-based research literature that has looked at sex differences in pain. Although the mechanisms are unclear, and unlikely to be direct,[59] women report greater incidence of chronic pain conditions and pain severity.[59] A similar literature has emerged with BMI, where robust associations with pain have been emerged but the mechanisms are unclear.[51] Cognitive function has been hypothesized as a key health marker that determines a range of health outcomes. It has been shown to protect against the emergence of different types of pain.[29] Depression severity is both a risk factor for pain, and a consequence of the emergence of chronic pain.[38] Depression is also closely related with cognitive function,[28] and is thought to be linked to central sensitization process that affect the experience of pain. Arthritis is a condition characterized by mounting chronic pain.[40] The risk of arthritis increases with age, alongside other chronic diseases, and for this reason, a measure of age is included as well. Years in education has been used in previous studies as a proxy for socioeconomic background,[75] which may contribute to pain in a number of ways (eg, environmental stressors, work history, health literacy), and is associated with better cognitive function in older adults.[43] Each of these also captures different mechanisms that may modulate, exacerbate, and maintain pain (see Table 1 for a summary).

Country-Level Psychological Effects: Cultural Norms, and Individualism, and Collectivism

We draw on insights from geographical psychology[10,31,60,61] to understand how cultural norms,[36,73] defined as country-level aggregates of individual measures, influence pain perception. In Fig 1, we present an adapted dynamic-process model proposed by Rentfrow et al,[60] which we utilize to specifically examine the effects of cultural and normative effects, as well as individual effects. That is, through a set of bottom-up dynamic processes, people exhibiting specific traits will come to cluster within regions and this will feedback to enhance the expression of these traits and associated behaviors, which will also then influence health. Indeed, geographical psychology has shown how personality traits are clustered within regions, and that geographical clustering is associated with regional variation in well-being and health.[10,60,61] These geographical clusters, in part, represent cultural norms of shared values that influence individual behavior.[61] For example, we may expect individual pain to be higher in countries with higher aggregate levels of depression or anxiety.

Importantly, geographical psychology research demonstrates that aggregate norms moderate individual traits.[61] For example, the 'situational strength hypothesis' suggests that when the context is strong (eg, higher aggregate depression), the influence of a trait (eg, individual depression) is reduced. However, when the context is weak, the relationship between a trait and an outcome becomes stronger.[19] Therefore, in this paper, we explore the ability of aggregate country-level factors to moderate the effect of individual-level risk factors.

We also explore the role of one other cultural norm, individualism/collectivism, on individual perceptions of pain. It has been claimed that the dimension of individualism-collectivism influences the way in which people respond to their own pain and the pain of other people.[3,69] However, much of this work has been done comparing across ethnicity as well as culture, and it is difficult to disentangle these competing factors. While this direct association has not been previously explored, there is evidence from the fear-avoidance model of pain indicating that the association between fear-avoidance and pain is greater in more collectivist cultures. Kroska[42] found a moderating effect of collectivism on the relationship between fear avoidance and pain severity in a meta-analysis of fear avoidance studies, using data from

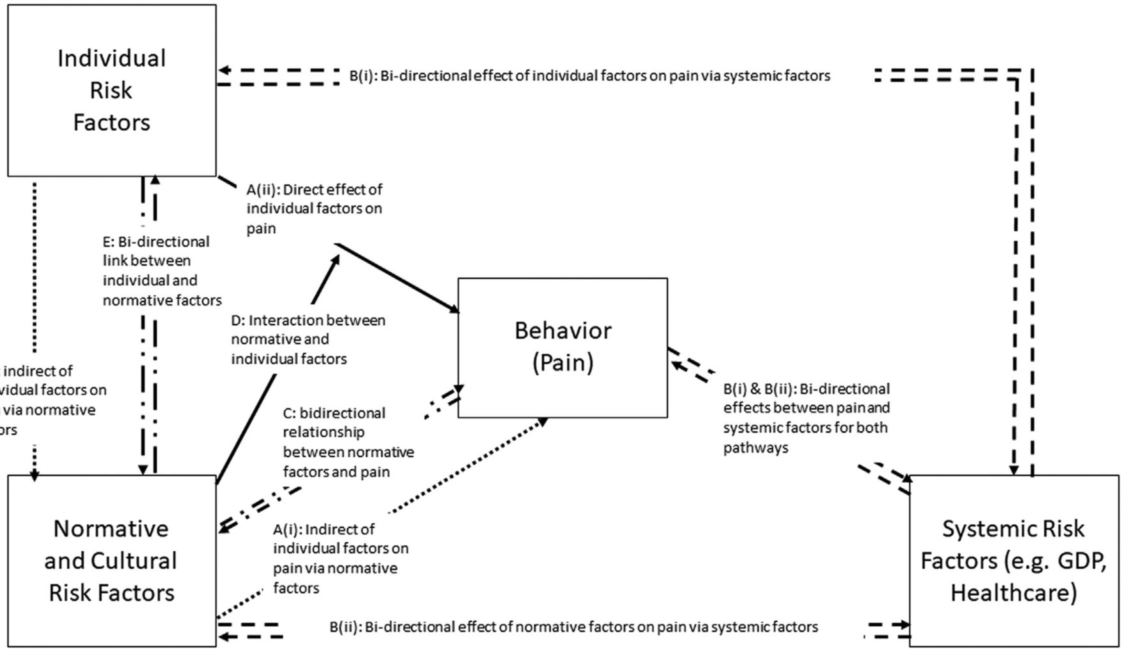

Figure 1. Dynamic process model of the relationship between psychosocial, normative, and systemic (ie, political) factors that influence pain. The A paths (A_i) and (A_{ii}) capture the effect of individual difference factors on behavior. This might occur *indirectly* (A_i) through cultural norms (dotted arrow: ··········) which are affected by individual differences. eg, people living in countries with higher levels of depression will also likely have higher levels of depression themselves, but higher country-levels of depression may be independently associated with increased reports of individual pain. This country-level expression of depression, reflects the dynamic process of the individual expression of depression, and this feeding back to enhance the expression of depression across a country/region (A_i). This can also be expressed *directly*, as higher levels of individual depression are associated with increased reports of individual pain (A_{ii}). The B pathways (B_i) and (B_{ii}) (dashed arrows: ▬ ▬ ▬) represent the dynamic bidirectional relationship between individual and normative factors on social, political and institutional systems, which influence behavior. Individual factors (B_i) are associated with these systemic factors, which affect behavior. As this relationship is bidirectional, behavior in turn may affect these systemic factors and subsequently individual factors eg, if higher levels of pain are reported by individuals this will be linked to greater healthcare provision, which feeds back to affect the expression of pain [(B_i) & (B_{ii})] and other individual factors. The same applies to normative factors (B_{ii}) as well eg, if country-level depression is high then more resources may be directed to address this, with this again feeding back to modulate the expression of depression in this case. In terms of pain these feedback loops may involve the acceptance of pain and psychological well-being or the availability of medication, sometime referred to as social multipliers). Thus, (B_i) & (B_{ii}) are indirectly linked to pain via systematic factors. The C path (dot and dash arrows: ▬ ▪ ▬ ▪) represents the social influence of pain on norms (ie, as individual express more pain, this may be translated into the greater expression of pain at the country-level or other associated country-level norms such as the average within country levels of depression). The path D reflects the moderation of the association between individual level factors (eg, depression) with individually reported pain, by the country-level normative variable (eg, country-level depression). The bidirectional E path (dash-dot-dot arrows: ▬ ▪ ▪ ▬) acknowledges that normative levels of individual difference in a population are an aggregate of individual variation, but also that social norms affect trait prevalence. Thus, in this figure we can see how there is a dynamic interplay of individual, social, cultural, and socio-political factors on pain.

the countries in which participants were sampled. The proposed explanation for this is that in cultures where collectivism is more prevalent, expressions of negative emotions, which may in some instances signify pain, are less likely to be supported. Alongside greater expressions of fear-avoidance,[45] this will result in greater severity when chronic, unavoidable pain emerges. Higher levels of individualism are also associated with wealth.[35] Therefore, an alternative hypothesis is that higher levels of individualism are associated with reduced pain because of a greater abundance of resources to address pain when it emerges. We test if this association between collectivism and pain is present.

Political and Economic Factors

The dynamic process model also indicates that there are also top-down processes that influence how traits may cluster within geographical regions, and ultimately affect health. These processes are reflected, in part, in a country's institutions and polices. Therefore, alongside country-level psychological factors, a country's political and economic characteristics can also influence pain,[15] and so we incorporate these into this analysis. Previous research on pain has focused on a narrow range of economic factors such as GDP rather than how wealth is utilised.[57,64] Thus, we extend the number of economic factors to account for expenditure on health care:[50] 1) Nurses per 1,000 people, 2) doctors per 1,000 people, and 3) health expenditure per capita, and 4) as well as the individual-level of wealth (GDP per capita).

Methods

Sample

These data were taken from waves 5 (collected in 2013) and 6 (collected in 2015) of the Study of Health, Ageing and Retirement in Europe (SHARE).[11-13]

Although a further wave of data has been released and another has been collected, these waves were selected because they have available sociopolitical data for the data collection years. Waves 5 and 6 contain data from 86,929 different respondents across 19 countries (Austria, Germany, Sweden, The Netherlands, Spain, Italy, France, Denmark, Greece, Switzerland, Belgium, Israel, Czechia, Poland, Luxembourg, Portugal, Slovenia, Estonia, and Croatia), of whom 47,523 completed both waves. Figure S1 and Tables S1 and S2 detail the sample used in our final model (n = 76,216). The individual country samples in the SHARE cohort are random probability samples of respondents from population registers (eg, national or municipal databases), lists of dwellings or social security databases. This comprised respondents with pain and individual difference data on at least 1 wave. A sensitivity analysis was also conducted on the respondents with pain data at both waves (*n* multiple = 43,256, Figure S2 in supplementary files). Because this study collapsed data across waves, the sample was not weighted.

Data Availability

The SHARE cohort data are publicly available for research usage at http://www.share-project.org/data-access.html.

Ethics

This is a secondary analysis of existing data. The SHARE cohort has received ethical approval for each wave of data collection from the University of Mannheim (waves 1−4), and the Ethics Council of the Max Planck Society (waves 5 onwards).

Measurements

Dependent Variable

Pain was measured using a standard 2 question indexing approach: "Are you troubled with pain" (Yes/No), and for respondents who responded "yes," "How bad is the pain most of the time? Is it…" (Mild/moderate/severe). This was combined into a single score from 0 to 3, with 0 being not troubled by pain and 3 being troubled by severe pain. As verbal rating scales, these sets of options have been used widely in the pain literature.[67] Verbal rating scales are valid indicators of pain, performing similarly to other, more elaborate pain measurements (eg, visual analogue scales or numeric rating scales), and are responsive to the introduction of pain, such as through a cold pressor paradigm.[26]

The following indicators were used in the modelling as risk factors.

Individual-Level Risk Factors

Individual factors were selected based on the previous literature indicating that they affect the experience of pain. Factors that did not have a meaningful 0 value were standardized. The descriptive statistics for these variables in all participants (n = 86,653) and those used in the final model (n = 76,216) are reported in Table S1. The number of respondents with data on time-varying indicators is reported in Table S2, and their average scores on these are in Table S3.

The following time-invariant indicators were included: Year of birth (z-scored), number of years in education (z-scored), and sex (0 = male, 1 = female). Time variant indicators were averaged across the waves in which the participant took part in the SHARE: BMI (z-scored), arthritis status, depression, and cognitive function.

For the *arthritis status* indicator, respondents were presented with a show card listing a series of chronic diseases (eg, Parkinson's disease), including rheumatoid arthritis, and osteoarthritis or other rheumatism as 2 separate categories. These were collapsed into a single variable for this analysis. Respondents were asked, "Has a doctor ever told you that you had/currently have any of the conditions on this card? With this, we mean that a doctor has told you that you have this condition and that you are either currently being treated for or bothered by this condition." Table S4 in the supplementary files shows just over 1 in 4 respondents that reported an arthritic condition at wave 5 did not affirm this at wave 6. Because we could not ascertain the reason behind this (eg, successful management, no longer seeking treatment), we averaged the scores across the 2 waves (0 = no arthritis at both waves, .5 = arthritis at 1 wave, 1 = arthritis at both waves).

Depression was assessed using the EURO-D,[56] a 12 item yes/no depression scale, which was averaged across the 2 waves. The items used in the SHARE are similar to the Geriatric Mental State (GMS-AGECAT).[20] The EURO-D scale has been validated with higher depression scores linked to poorer overall health.[32,54,55] To further confirm the validity of the EURO-D at the aggregate level, we show that aggregate EURO-D depression scores are negatively associated with aggregate cognitive ability ($\rho = -.770$, $P < .001$, N = 19), replicating the well-established negative association at the individual-level.[28,38]

Cognitive function was assessed using 4 components. Participants were randomly assigned to receive 1 of 4 lists of 10 words, given to them verbally by the interviewer. They had to recall as many of those words as possible (*immediate recall*). Participants then had to name as many animals as they could in 1 minute (*fluency*), subtract 7 from 100, then 7 again 4 more times (*numeracy*), and finally recall the list of words they were presented earlier (*delayed recall*). The scores in these 4 domains were then used as the basis for a principal components analysis (Table S5 in supplementary files), for which standardized component scores were extracted for each respondent. Parallel analyses indicated that a single component was the best fit in both waves. These factor scores were averaged across individuals if the participant took part in both waves. These questions have been used and validated in other panel data sets of ageing,[28,38] and individually have been shown to validly measure specific neuropsychological domains.[16,74]

Country-Level Factors: Cultural Norms

Individualism-collectivism values for each country were taken from Hofstede[35] and validated using the data from www.hofstede-insights.com. These ranged from 0 (totally collectivist) to 100 (completely individualistic) and were *z* scored (Table S6). The individualism-collectivism scores for each country were assigned by Hofstede and subsequent scholars, originally on the basis of cross-cultural data collected by Hofstede from IBM workers, but has been expanded with subsequent revisions.[35]

Aggregate norms were calculated by taking the *z*-scored average for individuals across each country on the individual risk variables (eg, arthritis diagnosis, depression, and cognitive function). This produces a cultural norm for each country on that measure.

Country-Level Factors: Socioeconomic and Political Variables

The following indicators were taken from the World Bank's World Development Indicators, hosted on the UK Data Archive (available at http://stats.ukdataservice.ac.uk/): Nurses and doctors per 1,000 people, health expenditure and GDP per capita. For each country, data were downloaded for each indicator between 2009 and 2016. Where possible, the average was taken at the 2013 and 2015 indices when SHARE data collection took place (further details see Table S7). All of the country-level variables were *z* scored. There were no data present for nurses per 1,000 people for 1 country (The Netherlands). The figure for this country was obtained from the OECD (https://data.oecd.org/healthres/nurses.htm), which has the number of nurses per 1,000 for the Netherlands in 2013. For doctors per 1,000 people, all countries had data for 2013, and some for 2015. Where possible, an average of the 2 was used; otherwise, the 2013 data were used. For health expenditure per capita, 2013 and 2014 data were available for all countries, so an average of the 2 was used. For GDP per capita, 2013 and 2015 data were available for all countries. Therefore, an average was used for those participating in both, and for those participating in 1 wave, the value for the year they participated was used. These were entered into the model as main effects without interaction terms.

Statistical Analysis

Geographical Mapping

The average levels of pain, depression, BMI, cognitive function, and arthritis diagnosis were overlaid upon a map of Europe. The geographic information system (GIS) data was taken from the natural earth project (https://www.naturalearthdata.com/downloads/). This included centroid data for each country. The figures were generated using the "spplot" function from the classes and methods for the spatial data ("sp") package.[9] For pain, spatial dependence, or the extent to which reports of pain were aggregated by the proximity of countries to one another, was assessed by calculating an inverse distance matrix (using the "dist" function in R's base package[58] on the longitude and latitude coordinates of each country's centroid). The extent to which there was spatial dependence was then tested using Moran's *I*, which is an index of autocorrelation. This was done using the 'Moran.I' function in the analysis of phylogenetics and evolution ("ape") package.[53]

Multilevel Models

Multilevel linear regressions were used to analyse these data. Averages of time-varying indicators were used because some participants and countries did not participate in both waves, meaning multilevel modelling techniques would not be possible due to the lack of intracluster variation. The multilevel models were estimated in STATA/SE 15.1.[65]

The multilevel model was built in 4 stages: 1) an intercept only model was fitted, with a random intercept for country (model 1) (Supplementary Table S8), 2) the individual-level variables were added to model 1 (model 2) (Table S9), 3) the aggregate norms were added to model 2 (model 3) (Table S10) and 4) cross-level interactions between the individual and country-level variables were added to model 3 (model 4) (Table 2). Cross level interactions were only tested within the same variable ie, individual by normative depression, and only if the normative effect was significant. This process was repeated for respondents only participating in both waves (Tables S11, S12 and S13), and incorporating number of comorbidities as well as arthritis (Table S14). The decision whether to retain more complex models was made using the Akaike Information Criterion (AIC).[1] The AIC is calculated by subtracting the model fit (the log-likelihood) from the number of parameters multiplied by 2. A lower AIC indicates a better fitting model. In the final model, *P* values are reported uncorrected, and corrected for the false discovery rate using the approach proposed by Benjamini and Hochberg.[8] The degree of variance explained at the country level was assessed by calculating intraclass correlation coefficients (ICCs). Bivariate associations between pain, and political and economic factors were tested using Spearman's rank correlation coefficient (ρ).

Individual-Country Level Interactions

Cross-level interactions were explored by calculating and plotting marginal means, using the *margins* command in STATA.

Table 2. **Multilevel Model With Cross Level Interactions**

MEASURE	B	SE	P	P (BH)	95% CI
Intercept	.297	.016	<.001	<.001	.266 to .328
Individual factors					
Year of birth (z)	−.018	.004	<.001	<.001	−.026 to −.011
Years in education (z)	−.063	.004	<.001	<.001	−.070 to −.056
Sex	.058	.006	<.001	<.001	.045 to .070
Arthritis status	.898	.008	<.001	<.001	.881 to .914
Depression	.135	.002	<.001	<.001	.132 to .138
BMI (z)	.093	.003	<.001	<.001	.086 to .099
Cognitive function	−.03	.004	<.001	<.001	−.042 to −.026
Country averages					
Individualism (z)	−.070	.027	.009	.017	−.122 to −.018
Years in education	.50	.022	.024	.040	.006 to .093
Depression	.077	.026	.003	.007	.025 to .128
BMI	−.0003	.048	.994	.994	−.095 to .094
Cognitive function	.018	.035	.599	.656	−.050 to .087
Arthritis status	−.035	.025	.173	.221	−.085 to .015
Resources					
Nurses per 1,000	−.093	.046	.041	.059	−.183 to −.004
Doctors per 1,000	−.080	.020	<.001	<.001	−.119 to −.041
Health spend per capita	.195	.109	.074	.100	−.019 to .408
GDP per capita	−.120	.058	.038	.058	−.232 to−.007
Individual x country average interactions					
Years in education	.009	.009	.343	.415	−.010 to .027
Depression	−.005	.002	<.001	.001	−.008 to −.002
Arthritis	.021	.008	.012	.021	.005 to .037
BMI	.004	.020	.849	.888	−.036 to .044
Cognitive function	.009	.012	.459	.528	−.015 to .033
Country (random intercept)	.004	.001			.002 to .007
Random intercept residual	.694	.004			.687 to .701

Note: ICC = .005, *se* = .002, *95% CI* = .003−.010 Log-likelihood = −94277.15, AIC = 188604.3, BIC = 188835.3. BH = Adjustment for false discovery rate using the Benjamini and Hochberg (56) method.

Results

Country-Level Geographical Clustering of Pain and Traits

Figure 2 (A-D) shows the distributions of pain (A), depression (B), cognitive function (C), and arthritis prevalence (D) by country (Figure S3 for BMI). These figures demonstrate variability between countries. Some countries report better outcomes on multiple measures such as pain, depression, and cognitive function (eg, Switzerland, The Netherlands), and some worse (eg, Portugal).

Pain Multilevel Models

All of the models showed that a statistically significant amount of variance in pain was explained at the country-level; around 4% when not adjusting for level 1 (individual) and level 2 (country) risk factors (Supplementary Table S7), falling to 2% when accounting for individual factors (Table S8), and <1% when including aggregate cultural norms (Supplementary Table S9 and Table 2). All the country-level economic indices were associated with country-wide variation in pain. Specifically, greater wealth (GDP $\rho = -.679$, $P = .002$), expenditure on health (health spending $\rho = -.700$, $P = .001$) and provision of healthcare resources (Nurses per 1,000, $\rho = -.500$, $P = .031$, Doctors per 1,000 $\rho = -.458$, $P < .05$) were all associated with reduced reporting of pain. This intercountry variation is represented by plotting the best linear unbiased predictor for the random intercept against the scaled (*z* scored) country-wide indices of wealth and health expenditure (Supplementary Figures S4-S7). There was no spatial dependence associated with reported pain (Moran's I = −.026, $P = .536$). This means that while the country-level economic indices were associated with pain, countries that are geographically closer do not experience more similar pain levels than countries further away. Instead, this indicates sociopolitical factors could drive these country-level differences.

All of the individual-level risk factors were associated with pain in the manner consistent with the previous literature[4,6,22,29,34,41,44,46–48,72] (Table 2, Supplementary Tables S8 and S9): older age had a small effect on pain (see sensitivity analyses reported in Tables S11. S12 and S13), women experienced greater pain, as did people who spent less time in education, had higher depression scores and had a higher BMI. Respondents reporting a diagnosis of arthritis reported greater pain, and respondents who performed better on the cognitive function tasks reported less pain.

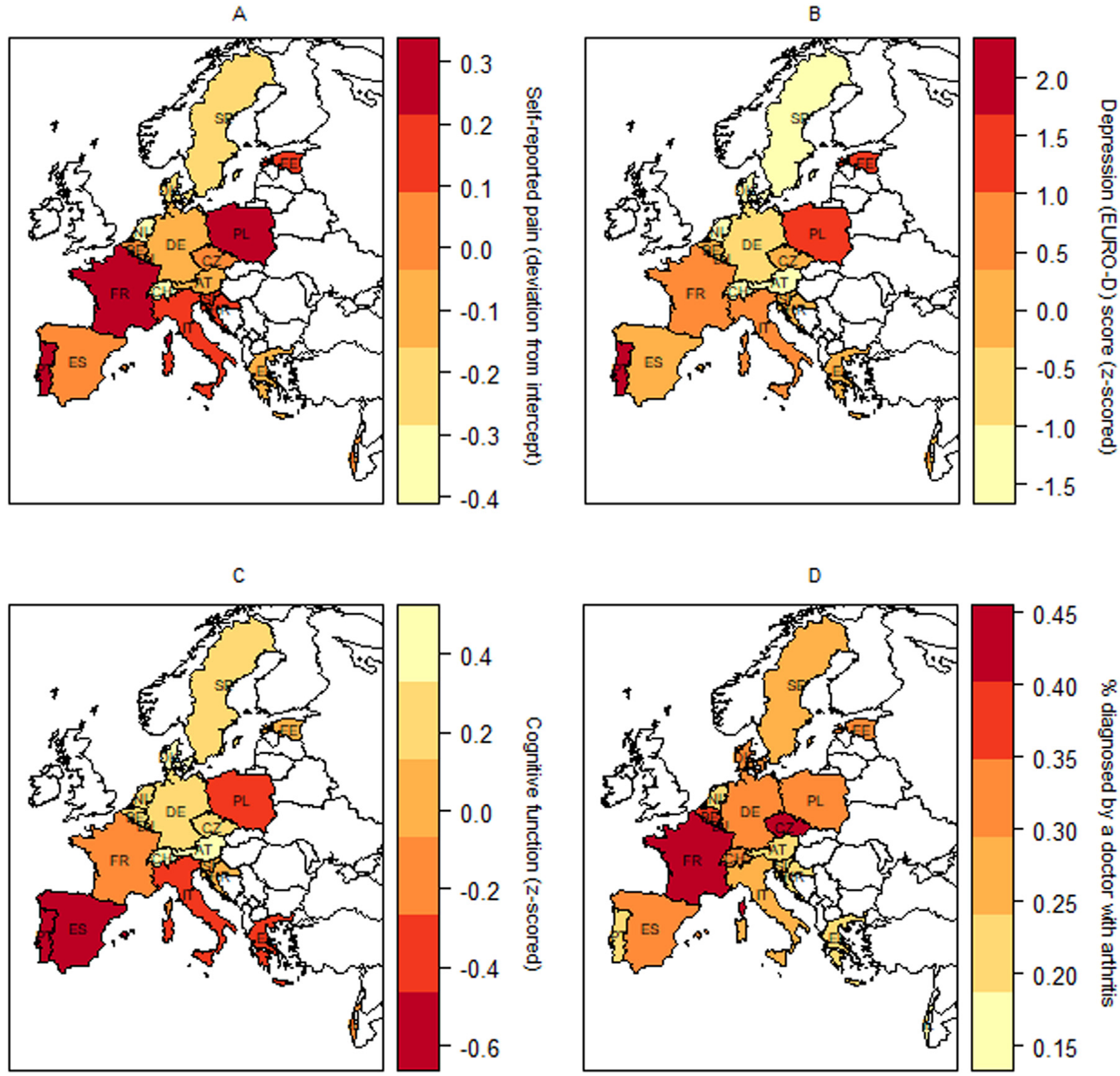

Figure 2. Maps of the aggregate levels of pain (A), depression (B), cognitive function (C) and arthritis diagnosis (D) by different country, for the 19 countries in the SHARE cohort. Countries in yellow report lower levels of the variable (less pain, lower depression, lower cognitive function, fewer arthritis diagnosis), and more in red. Pain is measured using the best linear unbiased predictor from a multilevel, random intercept model with country as a random effect.

AIC indicated that adding aggregate country-level norms improved model fit. People who live in countries that, on average, educated their populations for longer experienced more pain, as did people in countries reporting higher levels of depression. The effect of longer country-level education on pain was not anticipated, as the individual effect is in the opposite direction. This was the only instance in this analysis where this occurred. A number of factors may influence this, such as longevity or affluence, as more affluent countries have the resources to educate their populace for longer and the need for young people to enter the workforce is less urgent than the acquisition of advanced skills. However, neither the aggregate country-level cognitive ability nor an arthritis diagnosis affected individual pain. Collectivism was associated with reporting of greater individual-level pain. In terms of healthcare utilization and spending, the number of nurses, doctors, and GDP per capita was negatively associated with reported pain. Thus, greater resources were associated with reduced levels of reported pain. The nurses and GDP effects do not survive correction for the false discovery rate, so should be taken with caution in that regard.

Cross-level interactions were estimated between individual and country level effects when the country level effect was significant. There were also interactions between individual and country-level depression, and arthritis. These both show that the association between pain and the individual measure varies as a function of the country-level aggregate. In the case of depression, the interaction was negative (ie, pain-individual depression effect weaker when country-level depression greater), and in the case of arthritis positive (ie, pain-individual arthritis relationship stronger when aggregate arthritis greater).

Table 3. **Margin Slopes of the Interaction Between Individual Depression and Culturally Normative Levels of Depression (at Mean and +/− 1 and 2 SD's from the Mean)**

Slope of Individual Depression at Cultural Norm	dy/dx	se	P	95% C. I.
M −2 SD	.145	.004	<.001	.138−.153
M −1 SD	.140	.002	<.001	.135−.145
M	.135	.002	<.001	.132−.138
M + 1 SD	.129	.002	<.001	.135−.133
M + 2 SD	.124	.003	<.001	.118−.130

Table 4. **Margin Slopes of the Interaction Between Individual Reports of Arthritis Status and Culturally Normative Frequency of Arthritis (at Mean and +/− 1 and 2 SD's From the Mean)**

Slope of Individual Arthritis at Cultural Norm	dy/dx	se	P	95% C. I.
M −2 SD	.856	.020	<.001	.818−895
M −1 SD	.877	.013	<.001	.852−.902
M	.898	.008	<.001	.881−.914
M + 1 SD	.918	.011	<.001	.897−.940
M + 2 SD	.939	.017	<.001	.905−.973

The marginal means for the depression interaction are presented in Table 3 (and Figure S8), which contains the slopes between individual-level depression and pain at varying levels (mean and + or − 1 or 2 SDs) of country-level-aggregate depression. As can be seen, the association between individual-level depression and pain is stronger when country-level-aggregate depression is low (−1 and −2 SDs) and weaker when it is high (+1 or +2 SDs). Examining the 95% C.I.s shows that the association between individual-depression and pain is significantly weaker when country-level depression is at −2 and −1 SDs compared to when country-level depression at the mean and +1 and +2 SDs. Thus, individual-level depression is more strongly associated with pain when the country-level-aggregate of depression is low.

The second interaction between individual and collective diagnoses of arthritis is presented in Table 4 (and Figure S9), which contains the slopes between individual-level diagnosis and pain at varying levels (mean and + or − 1 or 2 SDs) of country-level-aggregate diagnosis. The association between individual-level diagnosis and pain is stronger when the country-level-aggregate is high (+1 and +2 SDs) and weaker when it is low (−1 or 2 −SDs). Examining the 95% C.I.s shows that the association between individual diagnosis and pain is significantly stronger when the country-level diagnosis is high (+2 SDs) than when the country-level aggregate diagnosis is low (−1 and +−2 SDs). Thus, in countries with more frequent diagnoses, the association between pain and individual diagnosis is strongest.

Sensitivity analyses (Tables S10, S11, S12, S13, and S14) indicated minimal differences between models collapsing across the 2 waves and those that did not have comorbidities additionally predicted pain on top of arthritis, but there were no country level effects nor cross level interactions.

Discussion

The findings of this study demonstrate for the first time how country-level norms and individualism-collectivism are associated with how individuals perceive pain, with these effects above and beyond the influence of individual-level risk-factors (eg, an individual's level of degression). Consistent with the literature, we observe numerous individual-level risk factors are associated with greater reported pain. However, for the first time, we show that country-level aggregates of depression or a diagnosis of arthritis are associated with increased reports of pain and moderate the effect of individual-level depression and arthritis diagnosis. We also show that reported pain is greater in countries with higher levels of collectivism. Finally, we highlight how greater economic resources that influence healthcare provision and an individual's standard of living are associated with less reported pain. These findings and their implications are detailed below.

Depression, Culture and Pain

Greater individual and aggregate country-levels of depression were positively associated with increased reports of pain. The individual-level effect is well documented and may reflect central sensitization[2] and inflammatory processes linked to both pain and depression.[24,70] The aggregate country-level effect has not been reported before. This likely reflects the legitimization of the expression of both pain and depression. Furthermore, we observe that the association between individual depression and pain is stronger in countries with lower aggregate depression. This pattern can be explained by the "situational strength hypothesis."[19] The situational strength hypothesis claims that the influence of a trait is stronger when the contextual information, or situation, is weaker. However, as the influence of the context increases, the influence of a trait diminishes. In this instance, an environment in which the context is stronger and depression is higher, may affect the point at which people start affirming they are experiencing some pain, discomfort or ill health. This ought to be tested further with other multinational datasets.

Diagnostic Information

A pain-based diagnosis provides information to allow an individual to understand and interpret their pain.[66] We find that in countries with more frequent arthritis diagnoses, the association between diagnosis and pain is stronger than when the country-level frequency of diagnosis is lower. This can be interpreted with respect to a dynamic process model,[60] whereby a person with diagnosed arthritis, living in a country where many are similarly diagnosed, has to compete with these additional patients for treatment. In such a scenario, accessing limited healthcare resources is likely to be directed towards those reporting the most severe levels of pain. As access to earlier treatments may be limited, this can lead to a positive feedback loop in pain reporting. Alternatively, the increased incidence of arthritis might be explained by other factors (eg, increased longevity). However, these explanations ought to be directly tested.

Individualism-Collectivism

Kroska (26) conjectured that higher levels of collectivism at the country-level were associated with higher pain severity. This is consistent with the idea that in collectivist cultures, where displays of individual negative emotions such as pain are typically discouraged,[3] a greater use of fear-avoidance strategies to cope with pain may result in higher levels of overall pain.[42] However, this may not be the only mechanism. An alternative mechanism is based on empathy. Empathy is higher in cultures where collectivism is more prominent.[33] In turn, increased empathy is associated with increased reports of pain.[63] These are testable, competing hypotheses which suggest different possible mechanisms for this; one based on the fear-avoidance model of pain, and one on the empathy-pain model. Further research ought to test between these competing accounts.

Economic and Political Effects

Several sociopolitical factors influenced pain. Increasing numbers of doctors and nurses per 1,000, and GDP per capita, were associated with less pain. While informative, these data provide limited information about the efficacy of healthcare spending on pain and so must be treated with caution. In particular, the analysis does not tell us how many doctors and nurses are in primary or secondary care. It also does not tell us about the relative spend on different treatment approaches, which also appear to differ between European countries.[15,76] For example, some countries differ in their use of pain management medication [76]. In contrast, other countries have been continuing attempts to limit access to total knee replacements, an elective surgical procedure common among people with knee osteoarthritis, on the disputed grounds of its cost and efficacy.[23]

These results have policy implications, indicating that pain treatment can be targeted at the individual-level (eg, reducing BMI, alleviating symptoms of depression) and by increasing the number of healthcare professionals. These results highlight the importance of political advocacy for charities or pressure groups that help people who experience chronic pain.[5,71]

Replication of Individual Risk Factors

We show that female gender, older age,[22,47,72] higher depression severity,[6,44,46,47] fewer years in education,[22,47] poorer cognitive function,[29,41,48] higher BMI[4,34,72] and being diagnosed with an arthritic condition were all associated with greater pain. Interestingly, these factors seem to be common across many countries, despite the existence of cross-national differences on some of these measures (eg, obesity[14]). It is reassuring to find these replicate in a large, multinational sample.

Strengths and Caveats

One of the strengths of this study is that all the countries studied have similar social insurance schemes for health provision. This similarity may limit generalizability, particularly to countries with vastly different systems (ie, the United States). Similarly, the focus on European countries excludes countries (eg, in Asia), where greater differences in collectivism are observed and so it is unclear whether these effect span the full range of individualism-collectivism. The size of the cross-level interaction effects are small. While these may question the clinical utility of these effects, at a population level these may bring meaningful benefits. Furthermore, they show theoretically that the effect of traits like depression on reported pain are influenced by the wider social context.

Sensitivity analyses were conducted to control for the consequence of aggregating across waves, finding no difference (Tables S11, S12, and S13). Nonetheless, there are caveats with using aggregated data, as some indicators (ie, depression) will change during that time. However, there was still a high degree of stability between waves (depression $r = .541$) and our primary interest is at the aggregated normative level. There is notable variation in responding to the arthritis question from wave to wave. By collapsing across the 2 data points, we have tried to capture this diagnostic uncertainty. It could be that respondents are not currently being treated or bothered by their arthritis (ie, they are undergoing a successful treatment regimen). It is unlikely to be due to measurement error − other studies using a similar set of questions find very small numbers of respondents retracting their arthritis diagnosis.[39] Sensitivity analyses also showed that similar results were observed when diagnosis was analysed within a single wave or with those who did not show variability in reported diagnosis at both waves. Similarly, while the measure of pain is derived from 2 items, there is evidence that this captures pain intensity or severity.[26]

The study uses a mixture of individual and aggregate level data. One concern with using aggregate level data is that it may produce anomalous results when applying it to individual behavior: the ecological fallacy, in which observed associations at the aggregate level are erroneously interpreted concerning the individuals in that group.[62] We have tried to mitigate the risk of ecological fallacy by looking at similar social welfare systems. Using a multilevel modelling framework, we examined the individual and aggregate effects for other associated factors (eg, depression).[68] However, we are aware of the ecological fallacy for the reported sociopolitical and cultural effects and these findings. We are also mindful that many other between-country differences (eg, working environments) might influence pain and individual responses, such as self-medication, which can contribute to these effects. While we controlled for a range of psychosocial factors, there are other key constructs that affect pain, but were not included due to limited coverage (ie, anxiety), or not being measured (ie, pain catastrophizing) in the SHARE cohort. These findings are cross-sectional and should be considered with that in mind, as causality cannot be inferred. However, we feel that we have established the importance of studying the impact of geographical and psychological factors on pain as an approach that has not been reported before. This opens up this field to pain research to explore the broader social, political, and cultural determinants of pain. Further consideration of interactions between individual and wider social, political and aggregate determinants of pain is warranted.

Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jpain.2023.03.006.

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