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Original Research

Comparison of musculoskeletal health in the general population between 2016/17 and 2022/3: A tapered matching study

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ABSTRACT

Objectives: To investigate changes in the prevalence of chronic pain (CP), high-impact chronic pain (HICP), and musculoskeletal health (MSK-HQ scores) before and after the COVID-19 pandemic.

Study design: Longitudinal cross-sectional study using data from two population-based surveys conducted in 2016/17 (PRELIM) and 2022/23 (MIDAS-POP).

Methods: Adults aged 35 and over registered with general practices in the West Midlands, UK, completed questionnaires including CP, HICP, and MSK-HQ. Entropy balancing was applied to match respondents across survey years on age, sex, deprivation, and ethnicity. Logistic and linear regressions estimated odds ratios (ORs) and mean differences. Subgroup analyses tested for interactions, and E-values were calculated to assess robustness to unmeasured confounding.

Results: CP prevalence increased from 35.6% in 2016/17 to 42.9% in 2022/23 (OR 1.36, 95% CI 1.22 to 1.51), and HICP from 15.5% to 22.4% (OR 1.57, 1.38 to 1.80). MSK-HQ scores among people with CP declined from 32.4 to 23.1, exceeding the minimal important change. Increases were more marked among women and people aged 35–54. Differences by deprivation and ethnicity were observed, although subgroup estimates for ethnicity should be interpreted cautiously due to small sample sizes. E-values suggested that the associations were moderately robust to unmeasured confounding.

Conclusions: Chronic pain prevalence and its burden have increased since the COVID-19 pandemic, alongside declines in musculoskeletal health. While some of this may reflect residual confounding, the findings underscore the need for targeted pain prevention and management strategies, particularly for working-age adults and underserved groups.

1. Introduction

There is increasing recognition of the need to lower the contribution of musculoskeletal conditions (MSK) and pain on both individual and population health.¹ MSK conditions, such as osteoarthritis and back pain, are leading contributors to disability worldwide and are typically characterised by chronic pain; one of the most common complaints in adults, affecting between one-third and one-half of the adult population in the United Kingdom.² Chronic pain is a frequent trigger for healthcare consultation due to the major impact it has on an individual's daily activities, and their physical and mental health.³ It is increasingly recognised for its contribution to premature mortality through its role in

limiting mobility and strong association with other chronic conditions (e.g. cardiovascular disease, chronic lung disease and mental health conditions).¹

Understanding prevalence trends in chronic pain will help us to predict future burden and develop targeted interventions for healthcare and public health. Population growth and ageing suggests that the number of people with chronic pain and who experience its impact will increase.² In addition, factors associated with greater impact of COVID-19 (e.g. socio-economic deprivation, lower incomes, non-White ethnicities, low-skilled occupations, co-morbidities, older age) are also associated with the incidence, prevalence and impact of chronic pain.⁴ COVID-19 brought widespread national restrictions and disrupted daily

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life and limited both the availability and delivery of health care services.⁵ Whilst the impact on cancer and cardiovascular disease have been reported the impact of this period on chronic pain is unclear.⁶

In this study we examine the pattern of prevalence of chronic pain, high impact chronic pain (i.e. chronic pain that impacts on daily activities) and musculoskeletal health in people with chronic pain before and after COVID-19 pandemic. To do this we apply tapered matching methods to compare pre-COVID-19 (from 2016/17) to post-COVID-19 (from 2022/23) estimates from the same geographical location balancing the responder samples on: age, sex, socioeconomic status, and ethnicity.

2. Methods

2.1. Study population

The data for 2016/17 and 2022/23 were collected in the PRELIM study (<http://doi.org/10.21252/5ag3-ta31>) and MIDAS-Population study (MIDAS-POP) (<https://doi.org/10.1186/ISRCTN10575867>) respectively. Both studies collected data from the same geographical area and sampled adults aged 35 years and older who were registered at general practices within 13 Primary Care Networks (PCNs) in North Staffordshire and Stoke-on-Trent, a relatively deprived area with 483,000 residents (30% of neighbourhoods are in the most deprived decile in England) and less ethnic diversity than England (91% identify as White). This area was particularly hit by COVID-19 demonstrated by the relatively high death rates compared to England's national averages.⁷ The MIDAS-POP study was approved on September 01, 2022 by Wales Research Ethics Committee 2 (ref: 22/WA/0256, details at <https://doi.org/10.1186/ISRCTN10575867>).

Ethical approval was obtained for the PRELIM survey and linkage to primary care EHR data from the North West-Greater Manchester East Research Ethics Committee (REC Ref: 15/NW/0735).

In England, GP registration is required to access non-emergency healthcare, making these registers an effective sampling frame for the general population. In the 2016/17 study, 18%–24% of the registered population aged 35 years and over from 11 practices were randomly selected and invited to take part in the survey. In the 2022/23 study, for each of 30 practices, 450 adults aged 35 years and over were randomly selected to take part in the survey; potential participants were selected regardless of whether they had consulted a GP.

2.2. Data collection

Between June 2016 and June 2017 potential participants were invited to complete a paper or online version of the PRELIM questionnaire. Between October 2022 and May 2023 potential participants were invited to complete a paper or online version of the MIDAS-POP questionnaire whilst some were conducted in-person “on-the-doorstep” and completed via a facilitator; the doorstep survey method was used to ensure sufficient responders from underserved communities (i.e. these are groups of people and communities who are usually not included in health research as often as they should be based on their population prevalence or health care needs/burden, they experience greater deprivation and are more ethnically diverse). The analysis focuses on those who completed a paper or online questionnaire. Sensitivity analysis was performed including those in 2022/23 who completed the in-person.

2.2.1. Outcomes

Three self-reported musculoskeletal health indicators were estimated and compared between time points.

- (i) Chronic pain (CP); defined as pain on most days or more in the past 6 months in the PRELIM questionnaire (*In the past 6 months, how often did you have pain? (Never, Some days, Most days, Every*

day) and in the past 3 months in the MIDAS questionnaire; both time frames produce similar estimates of chronic pain.⁸

- (ii) High impact chronic pain (HICP); defined as pain on most or all days in the previous 6 months in PRELIM and 3 months in MIDAS and that limited life or work activities on most or all days. This approach is used in the US National Pain Survey.⁸
- (iii) Musculoskeletal Health Questionnaire (MSK-HQ) score: a 14-item questionnaire that captures key outcomes that patients with musculoskeletal conditions have prioritized as important for use across clinical pathways.⁹ Scores range from 0 to 56, higher scores indicating better musculoskeletal health over the past 2 weeks.⁹ Mean MSK-HQ score in people with CP were derived and compared.

2.3. Covariates

We used the following covariates in our analysis to control for important differences in responder characteristics: age (years), sex, ethnicity (White/non-White) and socio-economic status (Index of Multiple Deprivation (IMD) based on residential postcode; this is classified into 10 deciles/categories based on the national ranking of index of multiple deprivation 2015).¹⁰ IMD 1 was taken as the most deprived category.

2.4. Statistical analysis

2.4.1. Preprocessing

To mitigate model dependence and address potential imbalances between the 2016/17 and 2022/23 groups, we employed coarsened exact matching (CEM), which is a monotonic imbalance bounding method that allows us to set a fixed level of imbalance *ex ante* (reducing model dependence) and to focus the comparison of exposed and non-exposed patients on regions of common support, ensuring sufficient overlap between the two sample populations studied here on key factors such as sex, age, IMD, and ethnicity.¹¹ These factors were coarsened using the default Sturges measure of bin size.¹² Respondents who did not fall within common support were excluded from the analysis. Subsequently, we applied entropy balancing to minimize differences in the distribution of covariates between the two population groups. This method involves maximum entropy reweighting of the 2022/23 sample, directly incorporating covariate balance into the weight function. Following a methodology similar to that of Silber et al.,¹³ we progressively balanced an increasing number of covariates.

The subsequent steps were predetermined based on logical groupings and order: (1) sex, (2) age, (3) IMD, and (4) ethnicity. Each step addressed specific questions regarding the potential reasons for outcome differences between the two patient groups. For instance, steps 1 and 2 assessed whether the observed outcome differences between 2016/17 and 2022/23 samples persisted after adjusting for key confounders of sex and age. Subsequent steps examined the impact of the other determinants. To ensure thorough covariate control, all covariates were balanced for mean, variance, and skewness. At each step, we analysed the resultant weights to identify any patients who were assigned unusually high weights, which could indicate undue influence.

To demonstrate the improvement in balance between the 2016/17 and 2022/23 samples, we compared the distribution of matched variables before and after matching using visual inspection of balance plots. Although step-by-step outcome estimations were generated, they are not shown in the tables due to their overall similarity. For clarity and parsimony, we report only the unadjusted and fully adjusted estimates in the main results.

2.4.2. Estimation

Logistic regression was used to measure the relative difference of binary outcomes (chronic pain and high impact pain; presented as odds ratios with 95% confidence interval) between 2016/17 and 2022/23

without balancing (i.e. crude relative difference) and then with the entropy balancing weights from each step (step 1-4), representing successively tighter control of differences in covariate distributions between the 2 comparative samples. We estimated the marginal prevalence of the two outcomes in each sample using weights from the final step of entropy balancing, ensuring covariates balance between the groups. In addition to odds ratios, we estimated marginal absolute prevalence differences between 2016/17 and 2022/23 from the weighted logistic regression models. For participants with chronic pain, the between-group mean differences in MSK-HQ were estimated using a linear regression model without balancing (i.e., crude difference) and with entropy balancing weights. Marginal estimation of the mean MSK-HQ in each sample was also calculated using weights from the final step of entropy balancing.

2.4.3. Subgroup analysis

Subgroup analyses employed a test of interaction to investigate whether there was evidence of a differential odds ratio (CP and HICP) and mean difference (MSK-HQ) across subgroups. Marginal estimations of the prevalence of chronic pain and high-impact pain, as well as the mean MSK-HQ, were also generated for each subgroup. We also repeated the matching process in sex and age-group to estimate odds ratio, prevalence and MSK-HQ mean and difference. Restricted by the sample size, the rematching was not processed for IMD and ethnicity; instead, full sample weights were applied, and interactions were tested to assess potential effect modification in these two subgroup analyses.

For CP and HICP, we fitted weighted logistic regression models including interaction terms between survey period and each subgroup variable and used Wald tests to obtain *P*-values for interaction. Subgroup comparisons were pre-specified, but we did not formally adjust for multiple testing and therefore findings need to be interpreted cautiously.

To contextualise the precision of weighted estimates, we calculated effective sample sizes (ESS) for the overall sample and for key subgroups (sex, age group, IMD decile, ethnicity) using the formula $(\sum W_i)^2 / \sum W_i^2$ (where *w* stands for the final weights) applied to the final entropy-balancing weights. ESS values and corresponding raw sample sizes are presented in [Supplemental Table 1](#).

2.4.4. Missing data

The percentage of missing data for each variable was $\leq 1\%$ in the 2022/23 respondent sample. In the 2016/17 respondent sample, there were no missing values for most variables except for ethnicity, which had a 12.8% missing rate. A missing category was introduced for categorical variables. Since the missing percentage for the continuous variable (age) was less than 1%, multiple imputation was not applied.

2.4.5. Secondary analysis and sensitivity analysis

For those who completed the in-person survey in 2022/23, the exact age of participants was unavailable; only two age categories (35-54 years and ≥ 55 years) were available for analysis. A secondary analysis was conducted by including responders from the “underserved populations” in the matching process (2022/23 with 2016/17) with age treated as a categorical variable.

To assess the robustness of our findings to potential unmeasured confounding, we conducted a sensitivity analysis using the E-value approach.¹⁴ Briefly, this seeks to quantify the minimum strength of association that an unmeasured confounder would need to have with both the exposure (MIDAS vs. PRELIM) and the outcome (e.g., chronic pain or musculoskeletal health) to fully explain away the observed association, conditional on the measured covariates.¹⁴ For binary outcomes (e.g., chronic pain and high-impact chronic pain), we calculated the E-value for the point estimate of the adjusted odds ratio (OR), as well as for the lower bound of its 95% confidence interval (CI) (see Supplemental Technical Note). For continuous outcomes (e.g., MSK-HQ score), where the effect size was represented by a standardized mean difference, the

E-value was calculated using: $E\text{-value} \approx e^{0.91 \times d}$. This formula estimates the minimum risk ratio that an unmeasured confounder would need to have with both the exposure and the outcome to reduce the observed association to null (see Supplemental Technical Note). We visualised the E-values alongside the main results to assess how susceptible the observed associations were to potential unmeasured confounding. Higher E-values indicate that stronger unmeasured confounding would be required to explain away the findings, suggesting greater robustness.

The analyses were conducted using Stata/MP, version 18.0 (Stata-Corp LLC).

3. Results

3.1. Study participants

In 2016/17 and 2022/23, 4226 and 2576 adults aged 35 years and over completed the questionnaire, respectively. Compared to the 2016/17 sample, the 2022/23 sample was more likely to be male, more deprived, and had a higher proportion of White ethnicity ([Table 1](#)). After the tapered matching ([Supplemental Fig. 1](#)), the distribution of matched variables between the 2016/17 (*n* = 3711) and the 2022/23 (*n* = 2432) matched samples were similar (e.g. mean age: 64.7 years (SD 12.4) in both samples) ([Supplemental Fig. 2; Table 1](#)).

3.2. Estimates of chronic pain and high impact chronic pain in 2016/17 and 2022/23

There were higher levels of chronic pain and high-impact pain in 2022/23, with odds ratios of 1.36 (95% confidence interval: 1.22 to 1.51) and 1.57 (1.38 to 1.80), respectively, in the final matched models. The marginal estimate of prevalence following matching for chronic pain was estimated to be 35.6% (95% CI: 34.0 to 37.2) in 2016/17 and 42.9% (40.9 to 44.9) in 2022/23, corresponding to an absolute prevalence difference of 7.3% (95% CI: 4.8 to 9.8). The marginal prevalence of high-impact pain was estimated to be 15.5% (14.3 to 16.8) in 2016/17 and 22.4% (20.8 to 24.1) in 2022/23, an absolute prevalence difference of 6.9% (95% CI: 4.8 to 9.0) ([Table 2](#)).

Compared to 2016/17, both women and men in 2022/23 had higher odds ratios for chronic pain and high-impact pain, with women having higher odds ratios [1.57 (1.34 to 1.83) and 1.79 (1.47 to 2.17)] for chronic and high-impact pain, respectively. Additionally, significantly higher odds ratios for chronic pain and high-impact pain were observed in the youngest age group (35-44 years) ([Fig. 1](#)). A clearer pattern of increased odds with greater deprivation was seen for high-impact pain, although this was less consistent for chronic pain. Formal tests of interaction indicated that the association between both chronic pain and high-impact chronic pain and survey period varied by sex, age group, socioeconomic deprivation and ethnicity, with all *P*-interaction values < 0.001 ([Fig. 1](#)). For ethnicity, estimates for the non-White subgroup were based on small denominators and effective sample sizes (2016/17: *n* = 13, ESS = 12; 2022/23: *n* = 22, ESS = 22; [Supplemental Table 1](#)), leading to wide confidence intervals and requiring cautious interpretation ([Fig. 1](#)). Marginal estimates of prevalence following matching for chronic pain and high impact pain were also estimated in each subgroup with absolute prevalence differences (2022/23 – 2016/17) indicating larger increases among women and adults aged 35–54 years ([Table 3](#)).

In the sensitivity analysis, including the in-person survey responders in the matching process, with age treated as a categorical variable, led to the rematching of the sample ([Supplemental Fig. 3](#)). After matching, the distribution of matched variables was comparable ([Supplemental Fig. 4; Supplemental Table 2](#)). Similar estimations for both odds ratios and absolute prevalence difference, as well as marginal prevalence of the two outcomes were obtained for men, women, participants aged 35-44 years, and those aged 55 years and over through the re-matching process ([Supplemental Table 3; Supplemental Fig. 5; Supplemental Table 4](#)).

Table-1
Population characteristics between PRELIM (2016/17) and MIDAS (2022/23).

	Raw data			CEM matched data			Entropy weighted data		
	PRELIM (2016/17)	MIDAS (2022/23)	P-value	PRELIM 2016/17)	MIDAS (2022/23)	P-value	PRELIM 2016/17)	MIDAS (2022/23)	P-value
N	4226	2576		3711	2432		3711	2432	
Exact Age, mean (SD)	63.8 (12.5)	64.3 (12.8)	0.124	64.2 (12.3)	64.7 (12.4)	0.124	64.7 (12.4)	64.7 (12.4)	0.999
Missing	0 (0.0)	10 (0.4)	n/a	0 (0.0)	0 (0.0)	n/a	0 (0.0)	0 (0.0)	n/a
Sex									
Female, n (%)	2402 (56.8)	1317 (51.1)	<0.0001	2132 (57.5)	1257 (51.7)	<0.001	51.7 (0.01)	51.7 (0.01)	0.9960
Male	1824 (43.2)	1230 (47.8)	Reference	1579 (42.6)	1175 (48.3)	Reference	48.3 (0.01)	48.3 (0.01)	Reference
Missing	0 (0.0)	29 (1.1)	n/a	0 (0.0)	0 (0.0)	n/a	0 (0.0)	0 (0.0)	n/a
IMD decile									
Most deprived	330 (7.8)	246 (9.6)	Reference	279 (7.5)	218 (9.0)	Reference	9.9 (0.01)	9.0 (0.01)	Reference
2	311 (7.4)	225 (8.7)	0.805	260 (7.0)	207 (8.5)	0.885	8.8 (0.01)	8.5 (0.01)	0.616
3	282 (6.7)	221 (8.6)	0.685	243 (6.6)	205 (8.4)	0.558	7.8 (0.01)	8.4 (0.01)	0.173
4	318 (7.5)	274 (10.6)	0.219	274 (7.4)	260 (10.7)	0.121	8.3 (0.01)	10.7 (0.01)	0.908
5	392 (9.3)	204 (7.9)	0.003	346 (9.3)	196 (8.1)	0.051	9.7 (0.01)	8.1 (0.01)	0.053
6	513 (12.1)	401 (15.5)	0.676	459 (12.4)	391 (16.1)	0.447	12.3 (0.01)	16.1 (0.01)	0.497
7	690 (16.3)	245 (9.5)	<0.0001	621 (16.7)	237 (9.8)	<0.0001	15.5 (0.01)	9.7 (0.01)	0.01
8	623 (14.7)	300 (11.7)	<0.0001	550 (14.8)	294 (12.1)	0.001	12.9 (0.01)	12.1 (0.01)	0.06
9	553 (13.1)	348 (13.5)	0.119	493 (13.3)	340 (14.0)	0.276	10.9 (0.01)	14.0 (0.01)	0.804
Least deprived	214 (5.1)	85 (3.3)	<0.0001	186 (5.0)	84 (3.5)	0.268	4.0 (0.01)	3.5 (0.01)	0.796
Missing	0 (0.0)	28 (1.1)	0.973	0 (0.0)	0 (0.0)	n/a	0 (0.0)	0 (0.0)	n/a
Ethnicity									
White	3654 (86.5)	2421 (94.0)	Reference	3638 (98.0)	2385 (98.1)	reference	98.3 (0.002)	98.1 (0.003)	reference
Non-White	31 (0.7)	127 (4.9)	<0.0001	13 (0.4)	22 (0.9)	0.007	0.3 (0.001)	0.9 (0.002)	0.08
Missing	541 (12.8)	28 (1.1)	<0.0001	60 (1.6)	25 (1.0)	0.058	1.3 (0.002)	1.0 (0.002)	0.327

Table 2
The entropy weighted overall odds ratio, absolute prevalence difference and prevalence of having chronic pain and high-impact pain between the PRELIM (2016/17) and MIDAS (2022/23) cohorts.

	Odds ratio (95% CI) ^a	Absolute prevalence difference (95% CI)	Estimated prevalence (95% CI)	
			PRELIM (2016/17)	MIDAS (2022/23)
	Chronic Pain			
Unweighted model	1.41 (1.27 to 1.57)	8.1 (5.7 to 10.5)	34.7 (33.2 to 36.2)	42.9 (40.9 to 44.9)
Final weighted model with balancing sex, age, index of multiple deprivation, and ethnicity	1.36 (1.22 to 1.51)	7.3 (4.8 to 9.8)	35.6 (34.0 to 37.2)	42.9 (40.9 to 44.9)
	High-impact Pain			
Unweighted model	1.68 (1.47 to 1.91)	7.5 (5.6 to 9.4)	14.7 (13.6 to 15.9)	22.4 (20.8 to 24.1)
Final weighted model with balancing sex, age, index of multiple deprivation, and ethnicity	1.57 (1.38 to 1.80)	6.9 (4.8 to 9.0)	15.5 (14.3 to 16.8)	22.4 (20.8 to 24.1)

^a In the odds ratio and absolute prevalence difference estimation, PRELIM (2016/17) sample was used as the reference group. Absolute difference in marginal prevalence (MIDAS [2022/23] – PRELIM [2016/17]), percentage points (95% CI).

3.3. Musculoskeletal health in people with chronic pain

Among participants with chronic pain, 1306/1464 from 2016/17 and 1042/1314 from 2022/23 (Main + MDC surveys) were matched (Supplemental Fig. 6). The matched variables are comparable between the two groups (Supplemental Fig. 7; Supplemental Table 5). The marginal mean MSK-HQ scores indicated lower musculoskeletal health in 2022/23 compared to 2016/17 (overall mean difference was -9.27 (95% CI: -10.43 to -8.11); the MSK-HQ score was 32.4 (31.8 to 33.0) in 2016/17 and 23.1 (22.1 to 24.1) in 2022/23 (Table 4). Similar levels of reduced musculoskeletal health in 2022/23 occurred for men and women and across IMD deciles. Although sample sizes were small and confidence intervals wide, larger reductions in musculoskeletal health in 2022/23 for those with chronic pain were observed in younger participants and non-White ethnicity (Table 4).

3.4. Musculoskeletal health in people with high impact chronic pain

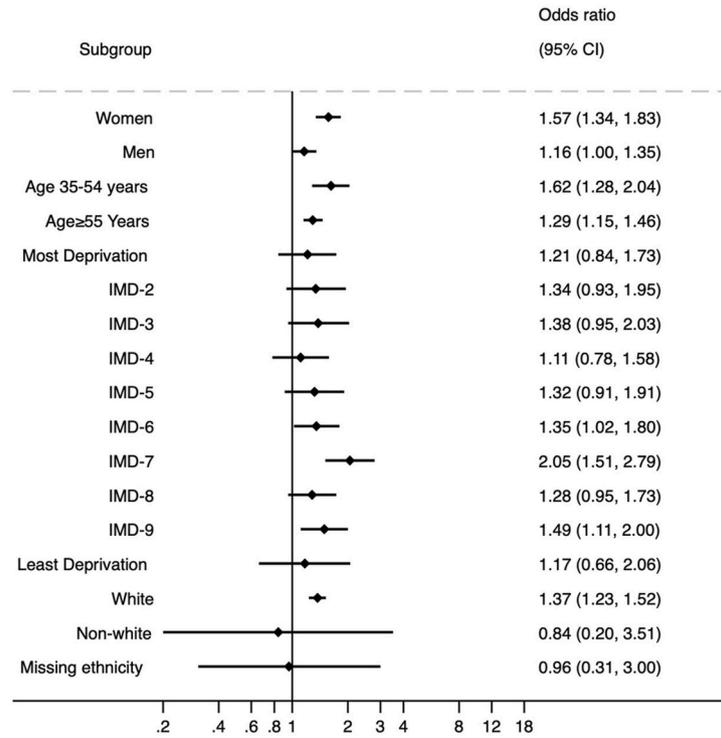
Among participants with high-impact chronic pain, 549/623 from 2016/17 and 533/733 from 2022/23 (Main + MDC surveys) were successfully matched (Supplemental Fig. 8); The matched variables are comparable between the two groups (Supplemental Fig. 9;

Supplemental Table 6). The marginal mean MSK-HQ scores were estimated at 25.1 (95% CI: 24.2 to 26.0) for 2016/17 and 17.1 (95% CI: 16.0 to 18.2) for 2022/23; mean difference was -7.99 (95% CI: -9.42 to -6.55) indicating worse health in 2022/23 (Table 4). Similar to the analysis of musculoskeletal health in those with chronic pain, the extent of lower musculoskeletal health in those with high impact chronic pain in 2022/23 was similar for men and women and across IMD deciles, with a larger reduction for younger participants and of non-White ethnicity (Table 4).

In the secondary analysis, the in-person survey responders were incorporated into the matching process, with age treated as a categorical variable. As a result, the sample were rematched for participants with chronic pain (Supplemental Fig. 10) and high impact pain (Supplemental Fig. 11). Following matching, the distribution of key variables was well-balanced for both the chronic pain (Supplemental Table 7) and high impact pain (Supplemental Table 8) groups.

Among those experiencing chronic pain, marginal mean MSK-HQ scores demonstrated a decline in musculoskeletal health from 2016/17 to 2022/23, with an overall mean difference of -8.17 (95% CI: -9.26 to -7.09). The MSK-HQ score decreased from 31.8 (31.2 to 32.5) in 2016/17 to 23.7 (22.8 to 24.5) in 2022/23 (Supplemental Table 9). Among those with high impact pain, a comparable pattern emerged,

Chronic Pain: MIDAS vs. PRELIM



High-impact Pain: MIDAS vs. PRELIM

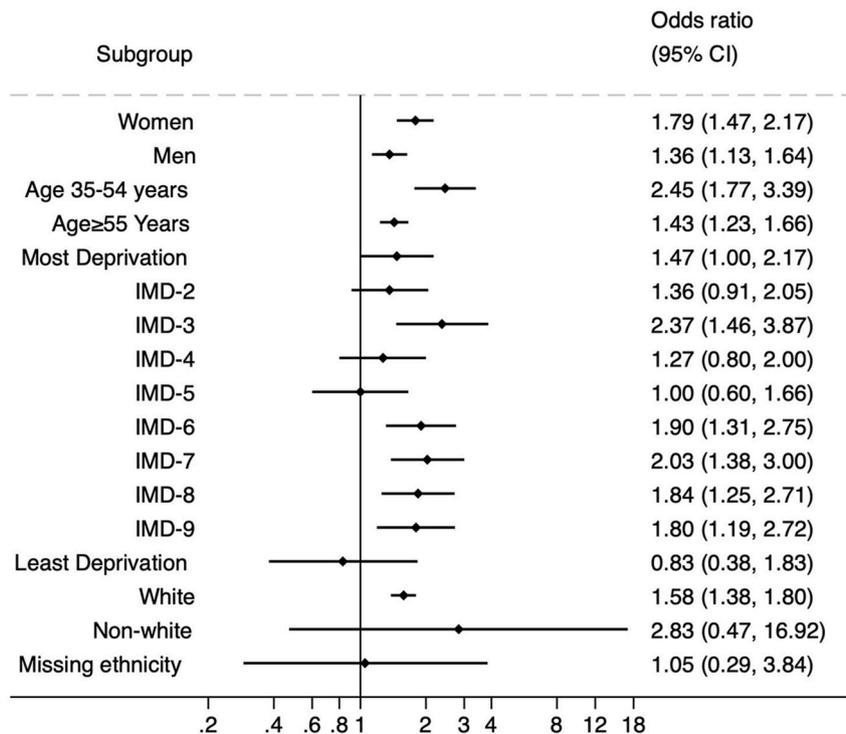


Fig. 1. Weighted odds ratio for having chronic pain and high impact pain between the MIDAS (2022/23; MAIN + MDC) and PRELIM (2016/17) cohorts: estimation from subgroup analysis

In the odds ratio estimation, PRELIM (2016/17) sample was used as the reference group.

P-values for interaction between survey period and sex, age group, IMD decile and ethnicity were all <0.001 (weighted logistic models including interaction terms).

For ethnicity, the non-White subgroup comprised 13 participants (ESS = 12) in PRELIM and 22 (ESS = 22) in MIDAS; results for this subgroup should be interpreted with caution due to small effective sample sizes.

Table 3

Estimated prevalence (95% CI) of chronic and high-impact pain in the PRELIM (2016/17) and MIDAS (2022/23; MAIN + MAC) cohorts: overall and by subgroups. Estimations were from the final weighted model.

Absolute difference in marginal prevalence (MIDAS [2022/23] – PRELIM [2016/17]), percentage points (95% CI).

	Chronic Pain			High Impact Pain		
	PRELIM (2016/17)	MIDAS (2022/23)	Absolute prevalence difference	PRELIM (2016/17)	MIDAS (2022/23)	Absolute prevalence difference
Overall	35.6 (34.0 to 37.2)	42.9 (40.9 to 44.9)	7.3 (4.8 to 9.8)	15.5 (14.3 to 16.8)	22.4 (20.8 to 24.1)	6.9 (4.8 to 9.0)
Sex						
Women	34.9 (32.5 to 37.3)	45.7 (42.9 to 48.4)	10.7 (7.1 to 14.2)	15.1 (13.3 to 17.0)	24.1 (21.8 to 26.5)	9.0 (6.0 to 12.1)
Men	36.3 (34.2 to 38.4)	39.9 (37.1 to 42.7)	3.6 (0.1 to 7.1)	16.0 (14.4 to 17.6)	20.6 (18.3 to 22.9)	4.6 (1.8 to 7.5)
Age-group						
35-54 years	28.6 (25.5 to 31.7)	39.4 (35.2 to 43.6)	10.6 (5.5 to 15.7)	9.1 (7.1 to 11.1)	19.8 (16.3 to 23.2)	10.7 (6.6 to 14.8)
≥55 Years	37.6 (35.8 to 39.5)	43.8 (41.6 to 46.1)	6.2 (3.3 to 9.1)	17.4 (15.9 to 18.9)	23.2 (21.3 to 25.1)	5.8 (3.4 to 8.2)
Socioeconomic deprivation						
Most Deprivation	49.2 (43.2 to 55.2)	54.0 (47.3 to 60.6)	4.7 (−4.2 to 13.6)	27.9 (22.5 to 33.2)	36.3 (29.8 to 42.7)	8.4 (0.1 to 16.6)
IMD-2	45.7 (39.6 to 51.9)	53.1 (46.3 to 59.9)	7.4 (−1.7 to 16.5)	26.3 (20.8 to 31.8)	32.7 (26.3 to 39.1)	6.4 (−2.0 to 14.8)
IMD-3	38.6 (32.4 to 44.9)	46.6 (39.7 to 53.4)	7.9 (−1.3 to 17.1)	13.8 (9.3 to 18.4)	27.6 (21.4 to 33.7)	13.9 (6.1 to 21.7)
IMD-4	35.5 (29.7 to 41.2)	37.8 (31.9 to 43.7)	2.4 (−5.9 to 10.7)	15.9 (11.4 to 20.3)	19.3 (14.4 to 24.1)	3.5 (−3.2 to 10.2)
IMD-5	32.3 (27.3 to 37.4)	38.7 (31.8 to 45.5)	6.3 (−2.1 to 14.7)	14.0 (10.3 to 17.8)	14.0 (9.1 to 18.9)	−0.06 (−6.3 to 6.1)
IMD-6	34.4 (29.9 to 38.9)	41.5 (36.6 to 46.4)	7.1 (0.5 to 13.8)	12.6 (9.5 to 15.8)	21.5 (17.5 to 25.6)	9.0 (3.7 to 14.7)
IMD-7	32.6 (28.8 to 36.4)	49.8 (43.4 to 56.2)	16.6 (9.8 to 23.4)	12.5 (9.9 to 15.2)	22.6 (17.2 to 27.9)	10.0 (4.1 to 15.0)
IMD-8	30.7 (26.8 to 34.6)	36.2 (30.7 to 41.7)	5.5 (−1.2 to 12.2)	12.1 (9.3 to 14.9)	20.2 (15.6 to 24.8)	8.1 (2.7 to 13.5)
IMD-9	30.2 (26.1 to 34.3)	39.2 (34.0 to 44.4)	9.0 (2.4 to 15.6)	10.2 (7.4 to 12.9)	16.9 (12.9 to 20.9)	7.0 (1.8 to 12.2)
Least Deprivation	27.8 (21.2 to 34.3)	31.0 (21.0 to 40.9)	3.2 (−8.6 to 15.0)	14.1 (9.0 to 19.3)	12.0 (5.0 to 19.1)	−2.1 (−10.9 to 6.7)
Ethnicity						
White	35.6 (34.0 to 37.2)	43.0 (41.0 to 45.0)	7.4 (4.9 to 9.9)	15.4 (14.2 to 16.7)	22.3 (20.7 to 24.0)	6.9 (4.8 to 9.0)
Non-White	40.6 (13.3 to 67.8)	36.4 (16.0 to 56.8)	−4.1 (−37.4 to 29.1)	14.2 (3.3 to 25.0)	31.8 (12.1 to 51.6)	17.8 (−14.3 to 53.9)
Missing ethnicity	36.1 (23.7 to 48.6)	35.3 (12.4 to 58.2)	−0.9 (−27.0 to 25.3)	22.6 (11.5 to 33.6)	23.5 (3.2 to 43.8)	0.9 (−22.0 to 23.9)

Table 4

Estimated mean and mean difference (with 95% CI) of MSK-HQ among participants with chronic and high-impact pain in the PRELIM (2016/17) and MIDAS (2022/23; MAIN + MAC) cohorts by overall and subgroup.

In the mean difference estimation, PRELIM (2016/17) sample was used as the reference group.

	Chronic Pain			High Impact Pain		
	Mean difference in MSK-HQ	Mean MSK-HQ		Mean difference in MSK-HQ	Mean MSK-HQ	
		PRELIM (2016/17)	MIDAS (2022/23)		PRELIM (2016/17)	MIDAS (2022/23)
Overall	−9.27 (−10.43 to −8.11)	32.4 (31.8 to 33.0)	23.1 (22.1 to 24.1)	−7.99 (−9.42 to −6.55)	25.1 (24.2 to 26.0)	17.1 (16.0 to 18.2)
Sex						
Women	−9.71 (−11.28 to −8.13)	33.1 (32.2 to 34.0)	23.4 (22.1 to 24.6)	−8.13 (−10.11 to −6.15)	25.7 (24.3 to 27.0)	17.6 (16.1 to 19.0)
Men	−8.73 (−10.45 to −7.00)	31.6 (30.7 to 32.4)	22.8 (21.3 to 24.3)	−7.76 (−9.79 to −5.73)	24.2 (23.1 to 25.4)	16.5 (14.8 to 18.2)
Age-group						
35-54 years	−12.26 (−14.86 to −9.66)	34.0 (32.6 to 35.4)	21.8 (19.6 to 23.9)	−10.75 (−14.24 to −7.25)	26.0 (23.4 to 28.6)	15.3 (13.0 to 17.6)
≥55 Years	−8.52 (−9.82 to −7.22)	32.0 (31.3 to 32.7)	23.5 (22.4 to 24.6)	−7.36 (−8.92 to −5.80)	24.8 (23.9 to 25.8)	17.5 (16.2 to 18.7)
Socioeconomic deprivation						
Most Deprivation	−9.50 (−13.04 to −5.96)	27.7 (25.4 to 30.0)	18.2 (15.5 to 20.9)	−6.93 (−10.25 to 3.61)	19.9 (17.7 to 22.1)	13.0 (10.5 to 15.4)
IMD-2	−9.44 (−12.78 to −6.11)	28.1 (26.4 to 29.9)	18.7 (15.8 to 21.5)	−9.32 (−13.12 to −5.52)	23.1 (20.9 to 25.3)	13.8 (10.7 to 16.9)
IMD-3	−10.67 (−14.66 to −6.67)	32.1 (30.1 to 34.2)	21.5 (18.0 to 24.9)	−6.18 (−10.97 to −1.39)	24.2 (21.1 to 27.3)	18.0 (14.4 to 21.6)
IMD-4	−10.23 (−13.97 to −6.49)	31.6 (29.5 to 33.8)	21.4 (18.3 to 24.5)	−7.43 (−11.63 to −3.24)	23.3 (20.7 to 25.9)	15.9 (12.6 to 19.2)
IMD-5	−7.15 (−11.47 to −2.84)	31.8 (29.6 to 33.9)	24.6 (20.9 to 28.3)	−7.42 (−13.53 to −1.31)	26.7 (23.1 to 30.3)	19.3 (14.4 to 24.2)
IMD-6	−10.00 (−12.95 to −7.05)	35.2 (33.6 to 36.9)	25.2 (22.8 to 27.7)	−10.27 (−14.20 to −6.33)	27.3 (24.6 to 30.1)	17.1 (14.2 to 19.9)
IMD-7	−9.74 (−12.97 to −6.51)	34.8 (33.4 to 26.3)	25.1 (22.2 to 28.0)	−9.13 (−13.34 to −4.92)	28.2 (25.8 to 30.6)	19.1 (15.6 to 22.5)
IMD-8	−7.45 (−10.83 to −4.08)	33.2 (31.7 to 34.8)	25.8 (22.8 to 28.8)	−6.72 (−11.04 to −2.40)	25.8 (23.4 to 28.2)	19.1 (15.5 to 22.7)
IMD-9	−8.28 (−11.60 to −4.95)	34.3 (32.6 to 35.9)	26.0 (23.1 to 28.9)	−5.43 (−10.02 to −0.83)	26.5 (23.5 to 29.6)	21.1 (17.7 to 24.5)
Least Deprivation	−11.51 (−18.47 to −4.55)	36.5 (33.7 to 39.2)	25.0 (18.6 to 31.4)	−9.92 (−17.8 to −2.04)	30.5 (26.4 to 34.7)	20.6 (13.9 to 27.3)
Ethnicity						
White	−9.05 (−10.22 to −7.88)	32.3 (31.7 to 32.9)	23.3 (22.3 to 24.2)	−7.92 (−9.36 to −6.48)	25.1 (24.1 to 26.0)	17.1 (16.0 to 18.3)
Non-White	−24.3 (−41.65 to −6.94)	41.8 (27.4 to 56.2)	17.5 (7.7 to 27.3)	insufficient		observations
Missing ethnicity	−22.45 (−35.53 to −9.37)	32.6 (29.2 to 36.0)	10.1 (−2.5 to 22.8)	−18.98 (−31.57 to −6.38)	25.5 (20.1 to 30.9)	6.5 (−4.87 to 17.9)

indicating worsening musculoskeletal health in the 2022/23 relative to 2016/17. The overall mean difference was −4.96 (95% CI: −6.34 to −3.57) with MSK-HQ scores falling from 24.5 (23.6 to 25.4) in 2016/17 to 19.6 (18.5 to 20.6) in 2022/23 (Supplemental Table 9).

Findings aligned with the primary analysis, showing comparable reductions in musculoskeletal health across men, women, and IMD deciles. However, greater declines were observed in younger participants and those from non-White ethnic groups with chronic pain (Supplemental Table 10).

The E-value for the associations between the exposure (MIDAS vs PRELIM) and the outcomes were as follows: 1.61 for chronic pain

(Supplemental Fig. 11), 1.82 for high-impact chronic pain (Supplemental Fig. 12), 3.05 MSK-HQ scores in the chronic pain population (Supplemental Fig. 13), and 3.07 for MSK-HQ scores in the high-impact pain population (Supplemental Fig. 14), respectively.

4. Discussion

4.1. Statement of principal findings

This study has used tapered matching methods to derive similar samples of adults aged 35 years and over living in the same geographical

area to compare the prevalence of chronic pain, high impact chronic pain and musculoskeletal health in people with pain between 2016/17 and 2022/23. This approach ensures that the change over time is not attributable to differences in the age, sex, deprivation or ethnicity profiles of survey respondents. However, it does not account for other unmeasured differences between the samples, such as possible changes in comorbidity burden following the pandemic, which may also have contributed to the observed differences. The first key finding is that the prevalence of chronic pain and high impact chronic pain have significantly increased between 2016/17 and 2022/23. Secondly, in those who experience chronic and high impact chronic pain, musculoskeletal health was significantly worse in 2022/23 compared to 2016/17. The change in MSK-HQ of 9 points between the two time points is notable, considering it has previously been shown to be sensitive to change with a MIC score of 5.5.¹⁵ Thirdly linked to these is the size of the problem; in 2022/23 within the matched samples chronic pain was reported by more than four out of ten respondents aged 35 years and over; high impact chronic pain by almost 1 in 4 respondents aged 35 years and over.

The increase in prevalence of chronic pain and high impact chronic pain occurred in men and women with a larger increase in women. With regards to age, the increase in prevalence of chronic pain and high impact chronic pain and reduction in musculoskeletal health was greatest in those aged 35 to 54 years old than in those aged 55 years and over. Increased prevalence of chronic pain and high impact chronic pain occurred for all deprivation groups other than the least deprived 10%. Prevalence of chronic pain increased in the White population whilst prevalence of high impact chronic pain increased more in the non-White populations. However, the latter finding should be interpreted cautiously due to the small number of non-White respondents and wide confidence intervals. The reduction in musculoskeletal health for those with chronic and high impact chronic pain occurred more in those aged 35 to 54 years and those of a non-White ethnicity, although this too is subject to uncertainty given the limited ethnic diversity in the study population.

Whilst this is the first study, to our knowledge, to explore change in chronic pain prevalence in the last 10 years, the level of increase estimated is similar to previous UK estimates from a longitudinal general population survey between 1996 and 2000¹⁶ but differs to prevalence estimates reported in the GP Patient Survey up to 2024 which have remained largely static over the same time period but is comparatively higher than US estimates.¹⁷ Reasons for the differences, particularly the GP Patient Survey could be the study population which is likely to be more diverse in our sample with the addition of the in-person survey targeting underserved groups, response bias to different surveys, differing definitions used e.g. joint pain in the GP Patient Survey versus chronic pain in our study. The difference in prevalence estimates in our study between the two time points might be explained by the impact of COVID-19 pandemic on our population during that period. Notably our findings identify much higher increase in younger adults which may lead to further increases in population prevalence in future years as this group ages. In line with other work, we also highlight that chronic pain prevalence and its impact (through high impact chronic pain and musculoskeletal health) is greater in lower socio-economic groups.¹⁷

The increase in chronic pain and high impact chronic pain, and reduction in musculoskeletal health, will be multifactorial, some attributable to COVID-19 itself, the wider implications of the infection and associated restrictions. New onset chronic pain as a result of COVID-19 infection, including joint pain which was reported to still be present 12 months after infection in some cases, increased likely due to a result of systematic inflammation caused by the virus itself and sequelae of treatments such as steroids.¹⁸ For many people with existing chronic pain the pandemic impacted on ability to access treatment and worsened psychological distress through social isolation and changes to employment.¹⁹

Risk factors for developing chronic and high impact chronic pain

such as obesity are increasing.²⁰ Trends in physical activity levels indicate that whilst in some populations there has been an increase in sports participation, the level of physical activity in some ethnic populations (such as South Asians) and those from low-income households is decreasing.²¹ Mental health in the UK has been on a decreasing trajectory since 2015, with a notable increase in mental distress observed during the early phase of the COVID-19 pandemic. For instance, the prevalence of clinically significant levels of mental distress rose from 18.9% (17.8 to 20.0) in 2018-19 to 27.3% (26.3 to 28.2) in April 2020.²² Factors such as lockdown restrictions, social isolation, changes to employment and increase in domestic violence have been associated with this decline. While these factors may have contributed to short-term increase in mental distress, the extent to which they have led to sustained changes in mental health and consequently influenced musculoskeletal health remained uncertain. Further longitudinal research is needed to determine whether the pandemic has had lasting effects on mental health that could impact MSK conditions.

The change in healthcare consultation methods with more remote consultations (telephone and video), asynchronous consulting (e.g. SMS messaging) and a reduction in face-to-face consultations may link with increased incidence and poor musculoskeletal health⁵ through under-reporting symptoms, delayed diagnosis and delay in appropriate treatment. The impact of postponed treatment for musculoskeletal conditions and other comorbidities in secondary care may have contributed to the increase in prevalence and poorer health. These changes likely explain the decrease in incident and prevalent MSK consultations in England during this time period, which also saw an increase in non-guideline analgesic prescribing for these conditions, particularly opioid prescriptions in more deprived areas.²³

4.2. Strengths and limitation of the study

The application of tapered matching in our study enabled nuanced balancing, through coarsened exact matching and entropy reweighting, which minimising model dependence and estimates of prevalence and musculoskeletal health on covariates. The iterative process systematically aligned distributions of age, sex, deprivation and ethnicity, reducing residual confounding and enhancing the reliability of effect estimates.¹³ Our findings align with previous work, underscoring its utility in real-world settings to derive equitable and reliable comparisons.²⁴ Another strength of our analysis is the inclusion of sensitivity analysis to assess the impact of unmeasured confounding. Using the E-value approach, we estimated the minimum strength of association an unmeasured confounder would need to 'explain away' the observed difference in musculoskeletal health between the two survey time points. For MSK-HQ scores within those reporting chronic pain, E-values indicated high robustness, and associations with anxiety were weaker than the thresholds, suggesting these results are unlikely to be fully explained by unmeasured factors. However, for CP and HICP, the E-values were lower than the observed associations with anxiety, indicating that unmeasured confounders may have influenced the observed increases. These findings highlight that while the decline in musculoskeletal health among those with chronic pain appears robust, some of the increase in chronic pain prevalence may be affected by residual confounding.

Study recruitment was conducted through registered primary care populations, aiming to reflect the local general population. However, the response rates (e.g. 54% in PRELIM), may introduce response bias and affect the representativeness of the sample. While participants from underserved communities were recruited into the study and our Patient Advisory Group contributed to the development of data collection methods and study material, the findings should be interpreted with caution regarding their generalisability beyond the local context. Future research with higher response rates and broader geographic coverage is needed to confirm these results at national level.

Whilst samples were matched for age, sex, deprivation and ethnicity,

which act as proxies for other factors (e.g. comorbidity), there are other factors that may have enhanced the matching (e.g. health literacy). Estimates may be impacted by responder bias with those with chronic pain more likely to respond (although the 2016/17 estimates are in line with other estimates of that period²⁵). The difference in recall (6 months in PRELIM and 3 months in MIDAS) for chronic and high impact chronic pain may have led to an underestimate on levels in 2022/23.²⁶

4.3. Implications for clinicians and policymakers

The absolute and increasing levels, particularly in younger individuals and those from deprived neighbourhood indicate that chronic and high impact chronic pain are serious public health issues, highlighting the need to review approaches to rehabilitation and the management of chronic pain. It indicates the need for tailored policies to target risk factors particular for those from deprived areas and support interventions to reduce impact. The prevalence indicates need for more resources and the need will be higher for some populations.²⁷ Matching need with appropriate interventions would help to reduce impact.

Engaging those from underserved communities who are most in need is crucial to understand local barriers to accessing and engaging with health care. Successful approaches to working with at risk groups to develop interventions include reaching people through community run organisations,²⁸ for working age people employment hubs could be utilised. Reducing barriers to accessing pain management is crucial and any interventions should include review of potential barriers, for example, living in rural areas²⁹ and language.³⁰

Further work focusing on engaging with populations in greater need would guide appropriate interventions; this would extend beyond healthcare, involve multi-sectors and involve co-creation with communities to develop approaches that can be successful in reducing incidence and impact of pain. Estimating the contribution of COVID-19 would be a starting point for identifying the reasons linked to an increase in prevalence and impact of pain. Whilst reasons for higher prevalence linked to socio-economic status has been examined, identifying why there is a greater increase in younger populations will help to target a reduction in incidence and impact.

Ethical statement

The MIDAS-POP study was approved by Wales Research Ethics Committee 2 (ref: 22/WA/0256). PRELIM was approved by [the North West-Greater Manchester East Research Ethics Committee (REC Ref: 15/NW/0735)]. Both studies used anonymised questionnaire and EHR data; no additional ethical approval was required for the secondary analyses presented in this manuscript.

Author contributions

DY, EP, RW, KPJ, and GP conceptualised the study and defined the analytical strategy; DY performed statistical analyses; DY and EP drafted the manuscript; DY, EP, RW, KPJ, JH, and GP review & editing the manuscript; DY, EP, RW, KPJ, JH and GP were active in funding acquisition. DY, JB, KPJ and RW have directly accessed and verified the underlying data reported in the manuscript. All authors contributed to the discussion and interpretation of data, critically reviewed the manuscript and approved the submission of the final version. All authors had full access to all the data in the study and accept responsibility to submit for publication.

Data sharing statement

Data are available upon reasonable request. Keele University is a member of the UK Reproducibility Network and is committed to the principles of the UK Concordat on Open Research Data. The School of Medicine and Keele Clinical Trials Unit make data available to bona fide

researchers upon reasonable request via open or restricted access through a strictly controlled access procedure. In the first instance, data requests and enquiries should be directed to medicine.datasharing@keele.ac.uk.

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Declaration of competing interest

The authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2026.106180>.

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