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Coal to swole: A survey of anabolic steroid use and muscularity concerns in coalfield areas of Wales

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ABSTRACT

Background: Growing male anabolic steroid use is often framed as symptomatic of a post-industrial masculinity crisis, but little quantitative evidence exists for this account. We examine whether steroid use is associated with geographic exposure to industrial decline, namely historical coal mining, and whether any association is mediated by masculine norms.

Methods: We fielded a quota-sampled survey of 18–49 year-old men in Wales (N = 1425). Data were geo-linked to the extent of historic coal mining locally to respondents. Generalised linear mixed models were fitted to test our hypotheses.

Results: Steroid use (odds ratio = 1.99, 1.10–3.60), but not body image (B = 1.06, −2.02–4.13), was positively associated with mining extent. However, this was not mediated by conformity to masculine norms.

Discussion: While use of steroids is more common in former mining areas, this is not due to more prevalent body image issues nor mediated by masculine norms. Thus, accounts of a post-industrial ‘thwarted masculinity’ do not fit the data. Steroid use in post-industrial areas is an issue for public health and these communities may benefit from targeted interventions to reduce risk of harms.

Once limited to elite athletes, anabolic steroids now attract a much broader range of users (Gestsdottir et al., 2021; McVeigh and Begley, 2017; Mullen et al., 2020). Sagoe et al. (2014) meta-analysed studies up to that date, suggesting that 6.4 % of men use steroids over their lifetime. These men are generally motivated by a desire for muscularity¹, for both instrumental and aesthetic reasons (Kotzé and Ajmani, 2021), but motivations vary among users (Christiansen et al., 2017; Zahnow et al., 2018). Steroids have been shown to substantially boost muscle growth (Hartgens and Kuipers, 2004; Johnson and O’Shea, 1969; Supasyndh et al., 2013), but their use is associated with a range of potential health risks, including dependence issues (Kanayama et al., 2009), fertility issues (de Souza and Hallak, 2011), and earlier mortality (Horwitz et al., 2019). This growth in use, therefore, has public health implications. Understanding the reasons behind this growth may help to implement

interventions to mitigate these harms.

Keane (2005) identifies discourses in accounts of the appeal of steroids, often centring on disordered masculinity, with users either understood as hypermasculine antisocial chauvinists or as victims of social changes which have denied them traditional paths to masculinity – masculinity either run amok or thwarted. The latter class of explanations frames steroid use, and men’s muscularity concerns more broadly, as a reaction to cultural and economic changes – the loss of traditional breadwinner roles, increasing gender equality, and the transition in western economies from industrial to service sector forms of employment. Such explanations suggest that steroid use and muscularity concerns are essentially disorders of neoliberal post-industrial capitalism (Hakim, 2015).

While Keane framed these explanations as tropes, of which she was

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¹ The term ‘swole’ from the title of this paper originates from a middle English word for ‘swelled’, which survived in some dialects of American English. Modern African American vernacular later adopted it to mean ‘highly muscular’ and it is now a popular slang term with that meaning.

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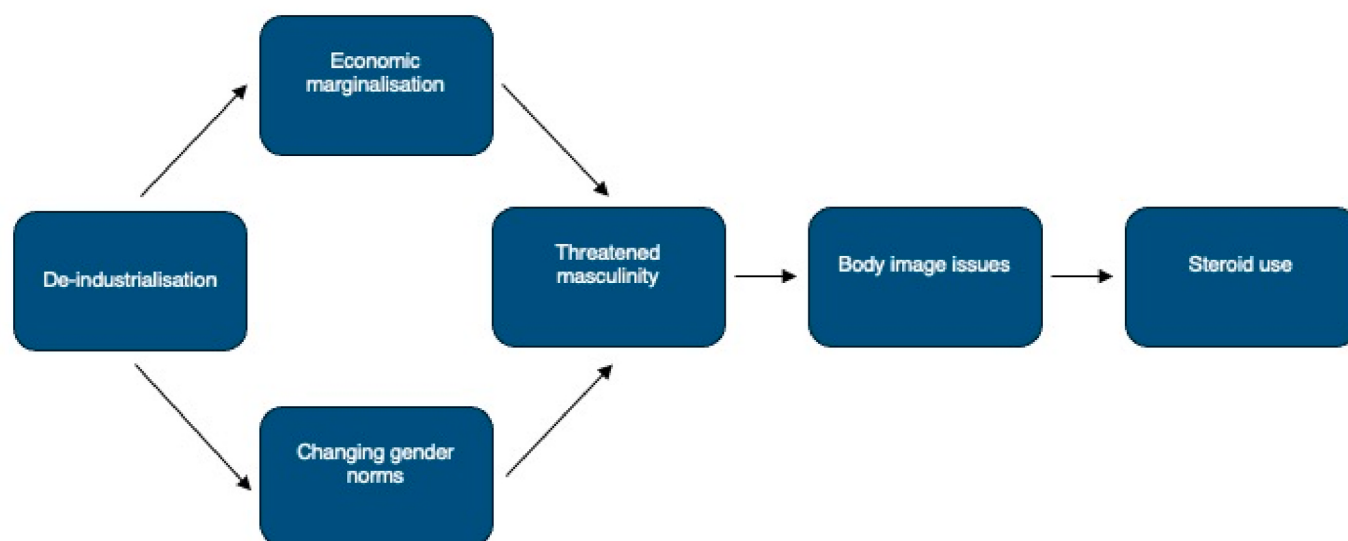


Fig. 1. Proposed mechanism by which de-industrialisation could lead to increased steroid use.

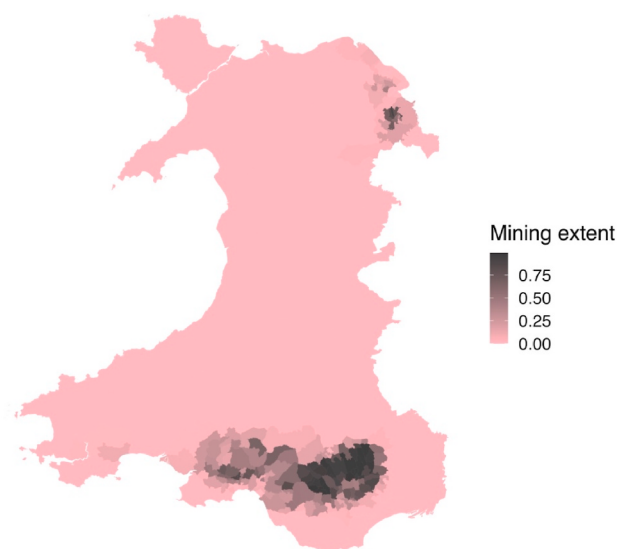


Fig. 2. Mining extent for each MSOA in Wales.

skeptical, it is worth considering the empirical evidence supporting this type of explanation. Evidence certainly exists to support a link between muscularity concerns and masculine norms. Meta-analytic evidence suggests that muscularity concerns are associated with measures of adherence to traditional norms of masculinity (Murnen et al., 2023). Social threats to men have been shown to be associated with increased measures of muscularity concerns, both experimentally (Mills et al., 2023; Mills and D'Alfonso, 2007), and observationally (Osa and Kelly, 2021). Building on a tradition of bodywork and embodied identities in sociology (Wacquant, 1995), qualitative work has shown masculinity be a highly embodied identity, with muscularity as a key aspect of this (Cranswick et al., 2020). As in the quantitative work, this research finds that men often respond to a threat to their masculine status with performances which embody their masculinity – displays of physical prowess and fortitude (Giazitzoglu, 2024). Theoretically, these phenomena are captured by the concept of protest masculinity: a reactive form of masculinity seen in economically marginalised settings.

Some evidence also links steroid use to these masculinity norms: the extent to which people endorse a set of norms of gendered behaviour.

These norms have been termed gender ideologies (Thompson et al., 1992), as they represent a normative stance towards what is appropriate masculine behaviour, rather than representing gender orientation. Halkitis et al. (2008) found, in a sample of New York men-who-have-sex-with-men, that steroid users were more likely to endorse traditional norms of masculine behaviour. Brady et al. (2019) found, similarly, that sexual minority Latino men who endorsed items measuring *machismo* were more likely to use steroids. Harris et al. (2019) found that steroid use was linked to higher rates of self-reported intrasexual competition in male novice bodybuilders. However, Kanayama et al. (2006), found no differences on a scale of male role attitudes or a measure of self-esteem between bodybuilders who did and did not use steroids.

This is only half of the story, however. A key element in this discourse about the growth of steroids is that the growth in their use is downstream of structural economic and cultural shifts which have disrupted access to traditional masculinity. In the same way which Giazitzoglu's (2024) rugby players responded to *personal* masculinity threats with displays of embodied masculinity, perhaps men in post-industrial settings respond to the implied *macro-scale* challenge to their masculinity with similar conspicuous displays of embodied masculinity – sometimes referred to as protest masculinity (e.g. Broude, 1990; Gater, 2024). Several qualitative studies explore cultures of bodybuilding and steroid use in post-industrial settings. Gibbs et al. (2022) report an ethnography of 'hardcore' gyms in post-industrial areas of England and frame gymgoers' bodybuilding as a way to retain a working-class understanding of masculinity in the absence of the industry in which it was traditionally understood – 'craft and graft' as they put it.

In the present paper we aim to empirically test a model of post-industrial changes in masculine roles as a social determinant of steroid use (see Fig. 1). We present results from a novel online survey carried out in Wales, with respondent data geo-linked to a measure of historical coal mining in their area of residence. We hypothesise that rates of steroid use and muscularity concerns will be positively related to the extent of coal mining locally, and that this relationship will show evidence of mediation by conformity to masculine norms and economic disadvantage.

Wales is a constituent nation of the United Kingdom that is home to one of the UK's most historically important coalfields. Welsh coal was a key ingredient of Britain's industrial revolution and the industry was central to the Welsh economy, employing a third of the male workforce

Table 1
Characteristics of the sample as a function of steroid use.

	Steroid non-users	Steroid users
N	1132	194
Mining extent (mean (SD))	0.23 (0.33)	0.30 (0.35)
Age (mean (SD))	32.13 (9.32)	33.09 (8.17)
Ethnicity (%)		
White	1029 (90.9)	186 (95.9)
Mixed/Multiple ethnic groups	23 (2.0)	4 (2.1)
Asian/Asian British/Asian Welsh	40 (3.5)	3 (1.5)
Black/African/Caribbean/Black British/Black Welsh	20 (1.8)	0 (0.0)
Other Ethnic group	20 (1.8)	1 (0.5)
Education (%)		
Non-degree	737 (67.9)	130 (67.7)
None	69 (6.4)	12 (6.2)
University degree	279 (25.7)	50 (26.0)
Household Income (%)		
Under £5000 per year	43 (3.8)	5 (2.6)
£5000 to £9999 per year	41 (3.6)	8 (4.1)
£10,000 to £14,999 per year	52 (4.6)	10 (5.2)
£15,000 to £19,999 per year	63 (5.6)	14 (7.2)
£20,000 to £24,999 per year	113 (10.0)	14 (7.2)
£25,000 to £29,999 per year	111 (9.8)	15 (7.7)
£30,000 to £34,999 per year	110 (9.7)	18 (9.3)
£35,000 to £39,999 per year	68 (6.0)	15 (7.7)
£40,000 to £44,999 per year	82 (7.2)	8 (4.1)
£45,000 to £49,999 per year	71 (6.3)	17 (8.8)
£50,000 to £59,999 per year	109 (9.6)	27 (13.9)
£60,000 to £69,999 per year	86 (7.6)	11 (5.7)
£70,000 to £99,999 per year	79 (7.0)	15 (7.7)
£100,000 and over	34 (3.0)	13 (6.7)
Don't know	35 (3.1)	0 (0.0)
Prefer not to answer	35 (3.1)	4 (2.1)
Finances (%)		
Having real financial problems and have fallen behind with many bills or credit commitments	80 (7.1)	28 (14.4)
Falling behind with some bills or credit commitments	112 (9.9)	20 (10.3)
Keeping up but it's a constant struggle	262 (23.1)	41 (21.1)
Keeping up but it's a struggle from time to time	357 (31.5)	55 (28.4)
Keeping up with all bills and credit commitments without any difficulties	236 (20.8)	41 (21.1)
Have no bills	53 (4.7)	6 (3.1)
Prefer not to say	32 (2.8)	3 (1.5)
Conformity to Masculine Norms Scale (mean (SD))	36.80 (6.46)	38.77 (7.85)
Muscularity subscale of Male Body Attitudes Scale (mean (SD))	44.79 (15.49)	49.01 (15.18)
Latent class (%)		
Non-user	1132 (100.0)	0 (0.0)
Health and recovery	0 (0.0)	73 (37.6)
Image and performance	0 (0.0)	121 (62.4)

in the 1921 census (Hudson and Beynon, 2021). The South Wales coalfield, the larger of two coalfields in Wales, is recognised as a national heartland, embodying the national character in public imagination (Williams, 1985). However, over the second half of the 20th century, the industry was wound down in favour of imported coal (Hudson and Beynon, 2021). The socioeconomic consequences were profound and there is a legacy of poverty in former mining communities which lasts to the present (Welsh Government, 2019).

The strength and bravery of coal miners were valorised as a realisation of idealised masculinity, with miners' bodies celebrated in art and culture (S. Ward, 2021). The cultural memory of this has outlived the industry itself, and significance of the loss of this hypermasculine role, even for young men who never worked in the pits themselves, is a theme of sociological studies of the area (M. R. M. Ward, 2018).

Former coalmining communities are an ideal case to test this putative pathway from economic change, through thwarted masculinity, to body image issues, and eventually steroid use. We report novel survey data looking at whether steroid use and muscularity concerns are greater

in coalfield areas than non-coalfield areas of Wales, and whether any such associations can be explained by differences in masculine norms and economic precarity.

1. Methods

1.1. Permissions

This project was approved by the Bangor University School of Psychology and Sports Science ethics committee.

1.2. Fieldwork

Data were collected using an online survey, run by the survey company Response.AI. Quota-sampling was used to aim for a 1200-person sample representative of the male population of Wales aged 18–49, in terms of age, education, ethnicity, ability to speak Welsh, and region of residence (Wales' seven local health boards). We also aimed to recruit a further non-representative 'boost' sample of 225 respondents living in areas with history of coal mining since 1960 (see Geographical Data section below for details) to ensure sufficient power to detect an association between coalfield residence and steroid use. Participants were recruited from the Lucid platform, where prospective respondents sign up to be sent online surveys in exchange for shopping vouchers. Respondents responding in suspicious patterns – finishing the survey very quickly (<150 s) or 'straight-lining' grids of items – or those with internet provider addresses associated with survey fraud, were excluded at source by Response.AI.

1.3. Geographical data

Survey data were linked to respondents' middle super output area (MSOA, a unit of statistical geography in the UK with a population of ~5000–10,000) of residence, using postcodes. Each MSOA's coalmining history was determined using two sources of data. Firstly, the MSOAs eligible for the boost sample were those where a pit was active since 1960, according to a list of Welsh pits, together with year of closure and longitude and latitude to cross reference with MSOA boundaries, kindly shared with the lead author by Mike Gill of the Northern Mine Research Society. Secondly, for analysis purposes, a measure of *mining extent* was computed for each MSOA by computing the proportion of each MSOA's area which had mineworks underground, using shapefiles of MSOA boundaries and of coalmine workings supplied by the Coal Authority, the UK's coal mining regulator. Mining extent had a theoretical range between 0 and 1 and an observed range between 0 and 0.99. See Fig. 2 for a map of mining extent.

1.4. Questionnaire

The survey was available in English or Welsh and is available at <https://osf.io/2ehpy/>. For the purposes of the current paper, the questionnaire contained items on: sociodemographic data, including age, gender (for the purpose of recruiting only men), ethnicity, ability to speak Welsh, and education; financial circumstances, including household income, financial stress (using a question used in the Welsh Government's National Survey for Wales: "Which one of the following statements best describes how well you [and your family/and your partner] are keeping up with your bills and credit commitments at the moment?", see tables for response options); the Conformity to Masculine Norms scale (Mahalik et al., 2003); and the Male Body Attitudes Scale (Tylka et al., 2005). The latter two measures are reliable, validated, and widely used measures of masculine cultural norms (Cronbach's alpha = 0.94, possible range: 22–88) and male body image (Cronbach's alpha = 0.91, possible range: 24–144), respectively.

The questionnaire asked about respondents' steroid use in the opening section of the survey, with the following item:

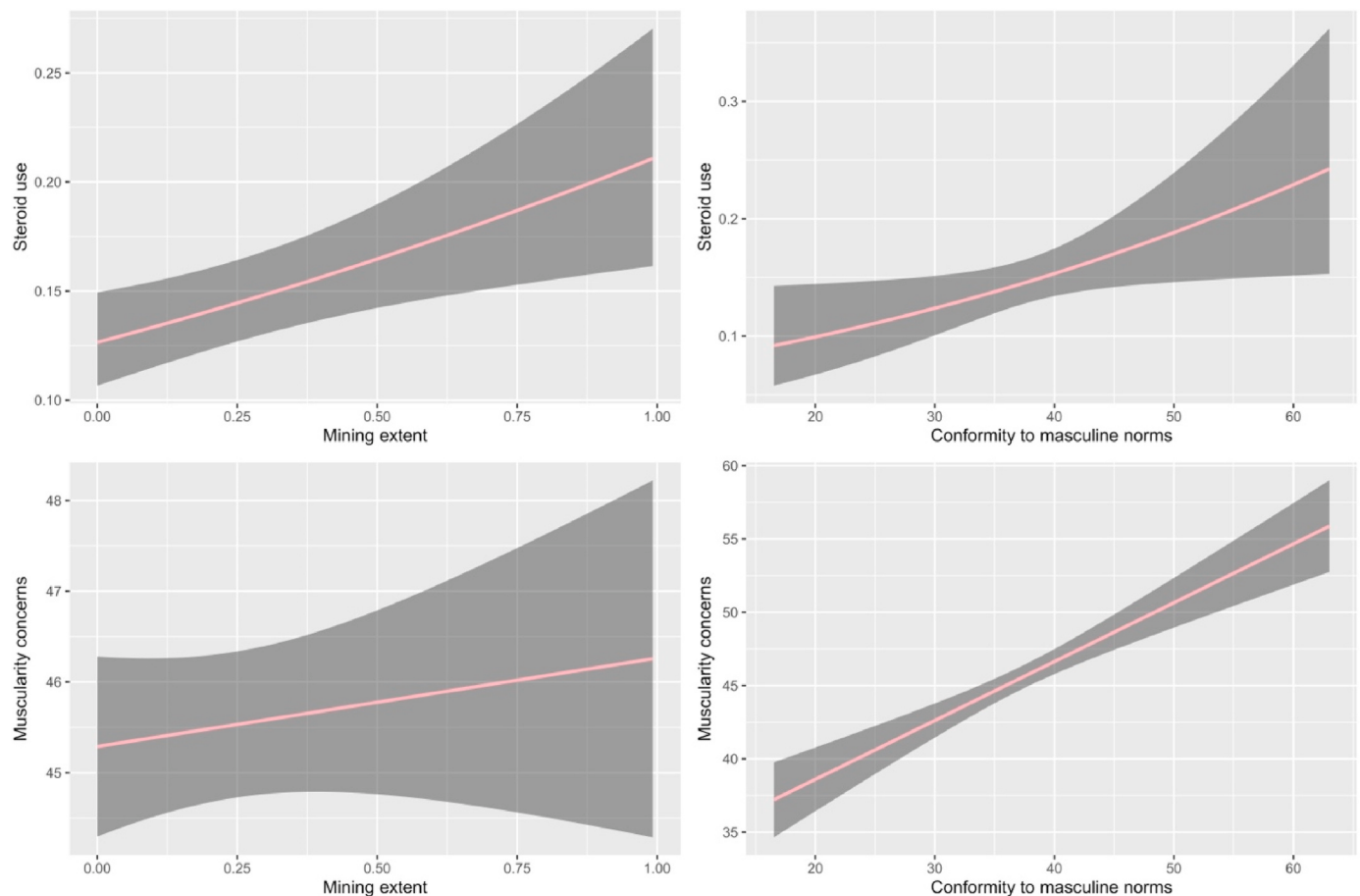


Fig. 3. Rates of steroid use (top panels) and mean scores on the muscularity subscale of the Male Body Attitudes Scale (bottom panels) as a function of mining extent (left-hand panels) and Conformity to Masculine Norms (right-hand panel).

“Anabolic steroids are substances taken to help build muscle more quickly, improve physical performance, cut fat, or to treat some health conditions. They are sometimes called, “gear”, “roids”, “juice”, “stackers”, “weight gainers”, or “Arnolds”.

Some common examples are: Testosterone (“Test”), Trenbolone (“Tren”), Nandrolone-Decanoate (“Deca”), Anadrol (“Drol”), Anavar (“Var”), Primobolan (“Primo”).

1.5. Have you ever taken anabolic steroids?”

This had the response options: “Yes, in the last 12 months”, “Yes, but longer than 12 months ago”, “No, but I have been offered them”, “No, and I have never been offered them”, “Not sure”, and “Prefer not to say”.

Respondents who gave one of the ‘yes’ options were asked a series of follow-up items. One was on their reasons for steroid use: “What reason did you use the anabolic steroids for? Please select all that apply” With the response options: “Help me to perform better at sports”, “So I can defend myself better”, “To help me recover from an injury”, “To impress other people”, “To look good”, “To make me more attractive”, “To train longer or harder”, “To help me to perform better at work”, “Because a test showed my natural testosterone was low”, “For other health reasons”, “For other, non-health reasons”, “Prefer not to say”. They were then asked “Which one of these reasons was the most important?” and this time picked only one from the list.

1.6. Analyses

1.6.1. Latent class analysis

Latent class analysis, implemented with the polCA package (Linzer and Lewis, 2011), was run on the reasons for steroid use given by those who gave one of the ‘yes’ responses to the steroid use item. For each respondent, a binary variable (yes, no) was included for each of the 11 reasons, plus a 11-level categorical variable giving their response to the main reason question. LCA models with between one and five classes were fitted to the data and the solution with the lowest Bayesian information criteria (Schwarz, 1978) was chosen. Each respondent was then coded with their class according to this model, or as a non-user.

1.6.2. Mixed effects models

Linear mixed-effects models (Brooks et al., 2017) were used to assess the relationship between steroid use, muscularity concerns (Male Body Attitudes Scale), and two key risk factors: mining extent and conformity to masculine norms. Models were tested both unadjusted and adjusted for potential confounders and mediators.

Missing data (including ‘prefer not to say’ responses) were multiply imputed, using the Amelia package (Honaker et al., 2011). Twenty iterations were used and all variables in the models were included in imputation, except MSA code, as categorical variables with >20 levels are not supported by Amelia. Models were also run without imputation, yielding similar results.

1.6.3. Steroid use

Binomial generalised linear mixed effects models were fitted, predicting steroid use (those giving one of the ‘yes’ responses to steroid use,

Table 2

Coefficients for models measuring association between steroid use and mining extent (terms in bold). Terms for Ethnicity - Black/African/Caribbean/Black British/Black Welsh ran from 0 to infinity due to low sample size in this group.

	Terms	OR	OR 2.5 %	OR 97.5 %
Model 1	Mining extent	1.99	1.10	3.60
Model 2	Mining extent	1.84	1.02	3.33
	Age	1.00	0.99	1.02
	Ethnicity - Mixed/Multiple ethnic groups	0.74	0.20	2.72
	Ethnicity - Asian/Asian British/Asian Welsh	0.44	0.13	1.49
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh			
	Ethnicity - Other Ethnic group	0.42	0.05	3.22
Model 3	Mining extent	1.84	1.00	3.41
	Age	1.00	0.98	1.02
	Ethnicity - Mixed/Multiple ethnic groups	0.74	0.19	2.87
	Ethnicity - Asian/Asian British/Asian Welsh	0.42	0.12	1.50
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	*	*	*
	Ethnicity - Other Ethnic group	0.35	0.04	2.92
	Finances - Falling behind with some bills or credit commitments	0.41	0.19	0.86
	Finances - Keeping up but it's a constant struggle	0.30	0.16	0.57
	Finances - Keeping up but it's a struggle from time to time	0.34	0.18	0.63
	Finances - Keeping up with all bills and credit commitments without any difficulties	0.38	0.20	0.74
	Finances - Have no bills	0.31	0.10	0.94
	Finances - Prefer not to say	0.21	0.05	0.87
	Education - None	0.73	0.34	1.55
	Education - University degree	1.00	0.65	1.55
	Income - £5000 to £9999 per year	1.75	0.45	6.85
	Income - £10,000 to £14,999 per year	1.92	0.51	7.18
	Income - £15,000 to £19,999 per year	1.95	0.55	6.88
	Income - £20,000 to £24,999 per year	1.15	0.34	3.94
	Income - £25,000 to £29,999 per year	1.19	0.34	4.19
	Income - £30,000 to £34,999 per year	1.85	0.54	6.29
	Income - £35,000 to £39,999 per year	2.39	0.68	8.41
	Income - £40,000 to £44,999 per year	1.14	0.31	4.26
	Income - £45,000 to £49,999 per year	2.00	0.55	7.26
	Income - £50,000 to £59,999 per year	2.51	0.76	8.29
	Income - £60,000 to £69,999 per year	1.26	0.34	4.66
	Income - £70,000 to £99,999 per year	1.90	0.54	6.71
	Income - £100,000 and over	3.81	1.00	14.50
Model 4	Mining extent	1.92	1.06	3.47
	Age	1.01	0.99	1.03
	Ethnicity - Mixed/Multiple ethnic groups	0.79	0.21	2.98
	Ethnicity - Asian/Asian British/Asian Welsh	0.36	0.11	1.24
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	*	*	*
	Ethnicity - Other Ethnic group	0.35	0.04	2.65
	Conformity to masculine norms	1.06	1.03	1.09
Model 5	Mining extent	1.80	1.00	3.21
	Age	1.01	0.99	1.03
	Ethnicity - Mixed/Multiple ethnic groups	0.79	0.21	2.94
	Ethnicity - Asian/Asian British/Asian Welsh	0.41	0.12	1.39
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	*	*	*
	Ethnicity - Other Ethnic group	0.41	0.05	3.17
	Male Body Attitudes Scale – Muscularity	1.02	1.01	1.03
Model 6	Mining extent	1.88	1.02	3.47
	Age	1.01	0.99	1.03
	Ethnicity - Mixed/Multiple ethnic groups	0.85	0.22	3.34
	Ethnicity - Asian/Asian British/Asian Welsh	0.33	0.09	1.18
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	*	*	*
	Ethnicity - Other Ethnic group	0.29	0.03	2.46
	Conformity to masculine norms	1.05	1.02	1.09

Table 2 (continued)

Terms	OR	OR 2.5 %	OR 97.5 %
Male Body Attitudes Scale – Muscularity	1.01	1.00	1.03
Finances - Falling behind with some bills or credit commitments	0.43	0.20	0.92
Finances - Keeping up but it's a constant struggle	0.32	0.17	0.61
Finances - Keeping up but it's a struggle from time to time	0.40	0.21	0.75
Finances - Keeping up with all bills and credit commitments without any difficulties	0.44	0.23	0.85
Finances - Have no bills	0.33	0.11	1.01
Finances - Prefer not to say	0.23	0.05	1.00
Education – None	0.73	0.34	1.58
Education - University degree	1.08	0.69	1.69
Income - £5000 to £9999 per year	1.62	0.41	6.40
Income - £10,000 to £14,999 per year	1.87	0.50	7.02
Income - £15,000 to £19,999 per year	2.08	0.58	7.44
Income - £20,000 to £24,999 per year	1.15	0.34	3.96
Income - £25,000 to £29,999 per year	1.07	0.30	3.80
Income - £30,000 to £34,999 per year	1.71	0.50	5.84
Income - £35,000 to £39,999 per year	2.19	0.61	7.79
Income - £40,000 to £44,999 per year	1.03	0.27	3.92
Income - £45,000 to £49,999 per year	1.90	0.52	6.92
Income - £50,000 to £59,999 per year	2.12	0.63	7.10
Income - £60,000 to £69,999 per year	1.04	0.28	3.92
Income - £70,000 to £99,999 per year	1.69	0.47	6.03
Income - £100,000 and over	2.94	0.76	11.41

with those responding 'Not sure' or 'Prefer not to say' treated as missing data) with a random intercept for each MSOA, to account for nesting of mining data. Residuals were weighted by sampling weights.

We fitted six models with mining extent as the fixed effect of interest:

- 1) an unadjusted model
- 2) adjusting for age (in years) and ethnicity (White, Mixed/multiple ethnic groups, Asian/Asian British/Asian Welsh, Black/African/Caribbean/Black British/Black Welsh, Other Ethnic group) to the unadjusted model
- 3) adjusting for age, ethnicity, financial circumstances, education (university degree, other qualifications, no formal qualifications), and household income (in bands, see Table 1)
- 4) adjusting for age, ethnicity, and conformity to masculine norms scores
- 5) age, ethnicity and the muscularity subscale of the Male Body Attitudes Scale
- 6) a model including all of the above variables.

We fitted three models with conformity to masculine norms as the fixed effect of interest:

- 1) an unadjusted model
- 2) adjusting for age and ethnicity to the unadjusted model
- 3) adjusting for age, ethnicity, financial circumstances, education, and household income.

1.6.4. Muscularity concerns

Gaussian linear mixed effects models were fitted to muscularity subscale scores from the Male Body Attitudes Scale, again with random intercepts for each MSOA and residuals weighted by sampling weights. Otherwise, the same nine models as above were fitted.

1.6.5. Steroid user class

Binomial generalised linear mixed effects models were run for each latent class of steroid use, to determine whether mining extent predicted membership of this class, as opposed to being a non-user or a member of another class of user. Versions of the models above were run with each of

Table 3

Coefficients for models measuring association between muscularity concerns and mining extent (terms in bold).

	Terms	B	B 2.5 %	B 97.5 %
Model 1	Mining extent	1.06	−2.02	4.13
Model 2	Mining extent	1.24	−1.86	4.33
	Age	−0.26	−0.36	−0.17
	Ethnicity - Mixed/Multiple ethnic groups	−4.04	−11.63	3.55
	Ethnicity - Asian/Asian British/Asian Welsh	3.30	−1.43	8.03
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	−9.41	−15.92	−2.90
	Ethnicity - Other Ethnic group	−1.54	−9.00	5.91
Model 3	Mining extent	1.02	−1.95	3.99
	Age	−0.30	−0.39	−0.20
	Ethnicity - Mixed/Multiple ethnic groups	−3.99	−11.48	3.50
	Ethnicity - Asian/Asian British/Asian Welsh	3.16	−1.55	7.87
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	−8.62	−15.11	−2.14
	Ethnicity - Other Ethnic group	−1.68	−8.96	5.61
	Finances - Falling behind with some bills or credit commitments	−1.71	−5.81	2.39
	Finances - Keeping up but it's a constant struggle	−3.21	−6.65	0.22
	Finances - Keeping up but it's a struggle from time to time	−7.46	−10.86	−4.06
	Finances - Keeping up with all bills and credit commitments without any difficulties	−9.69	−13.37	−6.02
	Finances - Have no bills	−8.93	−14.05	−3.82
	Finances - Prefer not to say	−9.07	−16.22	−1.93
	Education - None	0.41	−3.24	4.06
	Education - University Degree	−0.44	−2.47	1.60
	Income - £5000 to £9999 per year	4.55	−1.16	10.26
	Income - £10,000 to £14,999 per year	0.36	−5.39	6.11
	Income - £15,000 to £19,999 per year	3.55	−2.18	9.27
	Income - £20,000 to £24,999 per year	0.63	−4.73	6.00
	Income - £25,000 to £29,999 per year	2.94	−2.01	7.90
	Income - £30,000 to £34,999 per year	1.83	−3.24	6.90
	Income - £35,000 to £39,999 per year	1.25	−4.25	6.75
	Income - £40,000 to £44,999 per year	4.67	−0.61	9.95
	Income - £45,000 to £49,999 per year	1.93	−3.49	7.36
	Income - £50,000 to £59,999 per year	4.68	−0.30	9.66
	Income - £60,000 to £69,999 per year	4.26	−1.02	9.54
	Income - £70,000 to £99,999 per year	3.07	−2.31	8.45
	Income - £100,000 and over	7.28	1.21	13.35
Model 4	Mining extent	1.47	−1.58	4.51
	Age	−0.22	−0.32	−0.13
	Ethnicity - Mixed/Multiple ethnic groups	−3.63	−11.32	4.07
	Ethnicity - Asian/Asian British/Asian Welsh	2.19	−2.53	6.91
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	−10.24	−16.69	−3.78
	Ethnicity - Other Ethnic group	−2.54	−10.05	4.97
	Conformity to masculine norms	0.35	0.19	0.50
Model 5	Mining extent	1.27	−1.64	4.17
	Age	−0.26	−0.36	−0.17
	Ethnicity - Mixed/Multiple ethnic groups	−3.46	−11.05	4.12
	Ethnicity - Asian/Asian British/Asian Welsh	1.92	−2.78	6.62
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	−9.86	−16.29	−3.43
	Ethnicity - Other Ethnic group	−2.67	−10.08	4.73
	Conformity to masculine norms	0.35	0.19	0.50
	Finances - Falling behind with some bills or credit commitments	−1.59	−5.61	2.44
	Finances - Keeping up but it's a constant struggle	−3.09	−6.50	0.31
	Finances - Keeping up but it's a struggle from time to time	−7.23	−10.59	−3.88

Table 3 (continued)

Terms	B	B 2.5 %	B 97.5 %
Finances - Keeping up with all bills and credit commitments without any difficulties	−9.61	−13.23	−5.99
Finances - Have no bills	−9.28	−14.35	−4.22
Finances - Prefer not to say	−9.45	−16.37	−2.52
Education - None	0.56	−3.03	4.15
Education - University Degree	−0.06	−2.08	1.96
Income - £5000 to £9999 per year	4.30	−1.41	10.02
Income - £10,000 to £14,999 per year	0.29	−5.53	6.11
Income - £15,000 to £19,999 per year	4.12	−1.71	9.95
Income - £20,000 to £24,999 per year	0.67	−4.80	6.14
Income - £25,000 to £29,999 per year	2.59	−2.40	7.58
Income - £30,000 to £34,999 per year	1.45	−3.71	6.60
Income - £35,000 to £39,999 per year	0.88	−4.63	6.40
Income - £40,000 to £44,999 per year	4.45	−0.90	9.79
Income - £45,000 to £49,999 per year	1.62	−3.88	7.12
Income - £50,000 to £59,999 per year	4.04	−0.96	9.03
Income - £60,000 to £69,999 per year	3.50	−1.81	8.81
Income - £70,000 to £99,999 per year	2.45	−3.02	7.93
Income - £100,000 and over	6.08	−0.03	12.18

Table 4

Coefficients for models measuring association between steroid use and Conformity to Masculine Norms (terms in bold). Terms for Ethnicity - Black/African/Caribbean/Black British/Black Welsh ran from 0 to infinity due to low sample size in this group.

	Terms	OR	OR 2.5 %	OR 97.5 %
Model 1	Conformity to masculine norms	1.05	1.02	1.08
Model 2	Conformity to masculine norms	1.06	1.03	1.09
	Age	1.01	0.99	1.03
	Ethnicity - Mixed/Multiple ethnic groups	0.75	0.20	2.84
	Ethnicity - Asian/Asian British/Asian Welsh	0.33	0.10	1.12
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	*	*	*
	Ethnicity - Other Ethnic group	0.33	0.04	2.52
Model 3	Conformity to masculine norms	1.06	1.03	1.09
	Age	1.01	0.99	1.03
	Ethnicity - Mixed/Multiple ethnic groups	0.77	0.19	3.04
	Ethnicity - Asian/Asian British/Asian Welsh	0.30	0.08	1.10
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	*	*	*
	Ethnicity - Other Ethnic group	0.26	0.03	2.22
	Finances - Falling behind with some bills or credit commitments	0.41	0.19	0.87
	Finances - Keeping up but it's a constant struggle	0.29	0.15	0.57
	Finances - Keeping up but it's a struggle from time to time	0.36	0.19	0.66
	Finances - Keeping up with all bills and credit commitments without any difficulties	0.38	0.19	0.73
	Finances - Have no bills	0.28	0.09	0.85
	Finances - Prefer not to say	0.19	0.04	0.83
	Education - None	0.76	0.35	1.64
	Education - University Degree	1.05	0.67	1.63
	Income - £5000 to £9999 per year	1.67	0.42	6.67
	Income - £10,000 to £14,999 per year	1.87	0.50	7.04
	Income - £15,000 to £19,999 per year	2.10	0.59	7.52
	Income - £20,000 to £24,999 per year	1.13	0.33	3.91
	Income - £25,000 to £29,999 per year	1.06	0.30	3.78
	Income - £30,000 to £34,999 per year	1.68	0.49	5.77
	Income - £35,000 to £39,999 per year	2.11	0.59	7.55
	Income - £40,000 to £44,999 per year	1.09	0.28	4.14
	Income - £45,000 to £49,999 per year	1.93	0.53	7.02
	Income - £50,000 to £59,999 per year	2.27	0.67	7.62
	Income - £60,000 to £69,999 per year	1.09	0.29	4.10
	Income - £70,000 to £99,999 per year	1.69	0.47	6.04
	Income - £100,000 and over	3.12	0.80	12.15

Table 5

Coefficients for models measuring association muscularity concerns and Conformity to Masculine Norms (terms in bold).

	Terms	B	B 2.5 %	B 97.5 %
Model 1	Conformity to masculine norms	0.39	0.23	0.55
Model 2	Conformity to masculine norms	0.34	0.19	0.50
	Age	−0.22	−0.32	−0.13
	Ethnicity - Mixed/Multiple ethnic groups	−3.70	−11.39	3.99
	Ethnicity - Asian/Asian British/Asian Welsh	2.00	−2.70	6.69
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	−10.38	−16.83	−3.93
	Ethnicity - Other Ethnic group	−2.66	−10.18	4.85
Model 3	Conformity to masculine norms	0.35	0.19	0.50
	Age	−0.26	−0.36	−0.17
	Ethnicity - Mixed/Multiple ethnic groups	−3.53	−11.10	4.04
	Ethnicity - Asian/Asian British/Asian Welsh	1.77	−2.93	6.47
	Ethnicity - Black/African/Caribbean/Black British/Black Welsh	−9.96	−16.38	−3.53
	Ethnicity - Other Ethnic group	−2.79	−10.19	4.61
	Finances - Falling behind with some bills or credit commitments	−1.62	−5.65	2.40
	Finances - Keeping up but it's a constant struggle	−3.14	−6.54	0.26
	Finances - Keeping up but it's a struggle from time to time	−7.23	−10.59	−3.88
	Finances - Keeping up with all bills and credit commitments without any difficulties	−9.62	−13.23	−6.01
	Finances - Have no bills	−9.35	−14.41	−4.29
	Finances - Prefer not to say	−9.50	−16.44	−2.56
	Education - None	0.61	−2.98	4.19
	Education - University Degree	−0.10	−2.11	1.92
	Income - £5000 to £9999 per year	4.29	−1.43	10.01
	Income - £10,000 to £14,999 per year	0.31	−5.51	6.13
	Income - £15,000 to £19,999 per year	4.06	−1.78	9.91
	Income - £20,000 to £24,999 per year	0.63	−4.84	6.11
	Income - £25,000 to £29,999 per year	2.55	−2.44	7.55
	Income - £30,000 to £34,999 per year	1.40	−3.75	6.55
	Income - £35,000 to £39,999 per year	0.83	−4.71	6.36
	Income - £40,000 to £44,999 per year	4.48	−0.87	9.82
	Income - £45,000 to £49,999 per year	1.64	−3.86	7.14
	Income - £50,000 to £59,999 per year	4.09	−0.91	9.08
	Income - £60,000 to £69,999 per year	3.50	−1.80	8.81
	Income - £70,000 to £99,999 per year	2.45	−3.03	7.94
	Income - £100,000 and over	6.06	−0.05	12.16

these outcomes.

2. Results

2.1. Fieldwork

Fieldwork was completed July–September 2023. Achieving the boost sample from coalfield areas was challenging, so only 97 residents of MSOAs with 1960-onwards mining were recruited in the boost sample, with the rest of the boost sample being made up by male respondents aged 18–49 without other quota. The final achieved sample was 1427, with 383 from MSOAs with coal mining from 1960 onwards and 1044 from non-mining areas. However, 726 lived in an MSOA with a non-zero mining extent and 701 in an MSOA with a mining extent of 0.

In addition to screening out suspicious respondents at source, the frequency of each post code was checked. Ten post codes were shared by more than three respondents. As full UK post codes are generally only shared by ~15 properties, we excluded these 42 respondents. This left us with 1385 respondents, demographic details of which are presented in Table 1. Note that running analyses including these 42 respondents did not change the results of the analyses.

In terms of steroid use, 208 respondents (15.7 %) reported using them, 86 in the last 12 months and 122 longer ago. Checking the free text responses to items on types of steroids used and means of delivery revealed that some respondents had listed substances that were not anabolic steroids, often corticosteroids like hydrocortisone, but sometimes substances like cannabidiol oil; or had reporting the use of an inhaler, implying the use of corticosteroids for asthma. Respondents giving these responses were assigned to the non-user group. Respondents giving responses unfamiliar to the authors (e.g. 'slayjuice') were left in the user group, as these were plausibly slang terms for anabolic steroids. This left 194 users (14.6 %). See Table 1 for sample characteristics.

2.2. Latent class analysis

According to Bayesian information criteria, a two-class model best fit the data on reasons for steroid use. The first class, comprising 62 % of respondents, we termed the 'image and performance' group. Their three most common reasons for use were 'To look good', 'To train longer or harder', and 'Help me to perform better at sports'. The second class, comprising 38 % of respondents, we termed the 'health and recovery' group. Their three most common reasons were 'To help me recover from an injury', 'Because a test showed my natural testosterone was low', and 'For other health reasons'.

2.3. Linear mixed effects models

2.3.1. Steroid use

Higher rates of steroid use were reported in areas of Wales with greater mining extent (Fig. 3). This was confirmed by the generalised linear mixed effects models, which found odds ratios (ORs) of 1.99/unit increase in mining extent (i.e., 0 to 1). This association was slightly attenuated by, but robust to, adjustment for age and ethnicity, and to our measures of our candidate mechanisms: body image, financial circumstances, and conformity to gender norms. See Table 2 for all coefficients.

However, while there was a slight trend in the same direction for muscularity concerns, confidence intervals clearly overlapped with 0 in all models, see Fig. 3 and Table 3 for terms.

2.3.2. Masculine norms

As shown in Fig. 3 and Tables 4 and 5, conformity to masculine norms was positively associated with both steroid use (Table 4) and muscularity concerns (Table 5). The mixed effects models found that each additional point on the conformity to masculine norms scale was associated with an OR of 1.05 for steroid use, which remained broadly unchanged in the adjusted models, and a B of 0.39, which was very modestly attenuated in the adjusted models.

When splitting the steroid users into the image and performance and health and recovery groups, mining extent was associated with membership in the image and performance group, but not the health and recovery group, see Fig. 4 and Table 6. Again, this was confirmed by the linear mixed effects models, with ORs of 2.4 being attenuated but robust to all adjustments.

Likewise, higher Conformity to Masculine Norms predicted membership of the image and performance, but not the health and recovery, steroid user class, (see: Fig. 4 and Table 7).

Note that all analyses were run with and without multiple imputation, and results were unchanged by this.

3. Discussion

Using collected novel geo-linked survey data we tested whether male steroid use and muscularity concerns were driven by economic transition, mediated by conformity to masculine norms. As predicted, steroid use was more common in areas of Wales with greater historical coal-mining, but masculine norms did not explain this relationship. Thus, as

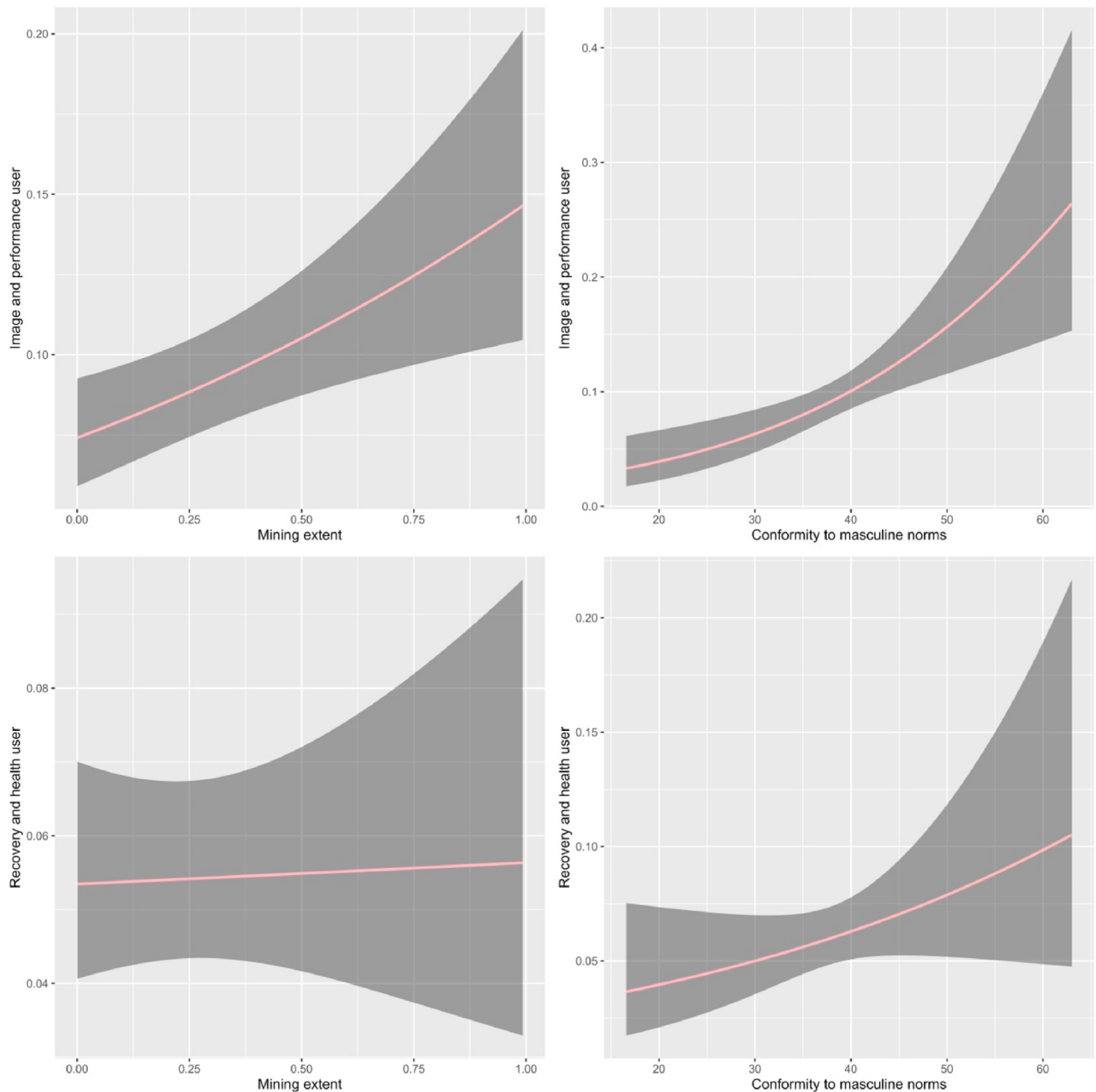


Fig. 4. Rates of membership in 'image and performance' (top panels) 'recovery and health' (bottom panels) steroid use subgroups as a function of mining extent (left-hand panels) and Conformity to Masculine Norms (right-hand panels).

Keane (2005) suspected, steroid use appears not to be simply a compensatory response to post-industrial thwarted masculinity.

If the link between post-industrial decline and steroid use is not mediated by thwarted masculinity, what might the mechanism be? Some accounts understand steroid use as an internalisation of capitalist values: competition, individualism, and commodification of self (Kotzé and Ajmani, 2021), rather than resistance to them, which the industrial decline account might imply. Instead of being a compensation for the loss of traditional pathways to masculinity, steroids are framed as a way of gaining the upper hand in an image arms race with one's peers. Thus, our results are not necessarily incompatible with steroid use as a reaction to post-industrial capitalism, but suggest that this account needs to

be carefully specified. Future work could also measure self-commodification, intra-sexual competition, and related psychosocial constructs.

Other possibilities include broader cultural differences in health attitudes and behaviours. Previous research has found greater Covid-19 vaccine hesitance in coalfield areas of Wales and Appalachia (Saville et al., 2023) and lower physical activity in deindustrialised English coalfields (Rind et al., 2014). Outside of health, there is also evidence for differences in cultural values, and even personality traits, on and off historical coalfields. Coalfields still have higher levels of trade union membership (Beynon et al., 2021), lower levels of entrepreneurialism (Stuetzer et al., 2016), lower political trust (Abreu and Jones, 2021),

Table 6

Coefficients for models measuring association between belong to each of the two classes of steroid users, image and performance users in the left-hand columns and health and recovery users in the right-hand column, and mining extent (terms in bold). Some terms for ethnicity groups ran from 0 to infinity due to low sample size in these groups.

		Image and performance user				Health and recovery user		
		Terms	OR	OR 2.5 %	OR 97.5 %	OR	OR 2.5 %	OR 97.5 %
Model 1	Mining extent	2.44	1.15	5.18	1.19	0.52	2.74	
Model 2	Mining extent	2.21	1.04	4.69	1.16	0.50	2.72	
	Age	1.01	0.99	1.04	0.99	0.96	1.01	
	Ethnicity - Mixed/ Multiple ethnic groups	0.54	0.09	3.10	1.04	0.18	6.07	
	Ethnicity - Asian/ Asian British/ Asian Welsh	0.26	0.04	1.95	0.71	0.16	3.13	
	Ethnicity - Black/ African/ Caribbean/Black British/Black Welsh	*	*	*	*	*	*	
Model 3	Ethnicity - Other Ethnic group	*	*	*	0.93	0.11	7.53	
	Mining extent	2.19	1.04	4.62	1.17	0.48	2.86	
	Age	1.01	0.99	1.04	0.99	0.96	1.02	
	Ethnicity - Mixed/ Multiple ethnic groups	0.65	0.11	3.78	0.96	0.16	5.90	
	Ethnicity - Asian/ Asian British/ Asian Welsh	0.28	0.04	2.10	0.69	0.15	3.29	
	Ethnicity - Black/ African/ Caribbean/Black British/Black Welsh	*	*	*	*	*	*	
	Ethnicity - Other Ethnic group	*	*	*	0.86	0.10	7.53	
	Finances - Falling behind with some bills or credit commitments	0.55	0.23	1.35	0.34	0.10	1.14	
	Finances - Keeping up but it's a constant struggle	0.32	0.14	0.71	0.46	0.18	1.14	
	Finances - Keeping up but it's a struggle from time to time	0.38	0.17	0.82	0.43	0.18	1.05	
	Finances - Keeping up with all bills and credit commitments without any difficulties	0.33	0.14	0.75	0.65	0.26	1.65	
	Finances - Have no bills	0.38	0.10	1.50	0.30	0.05	1.75	
	Finances - Prefer not to say	0.18	0.02	1.41	0.57	0.09	3.72	
	Education - None	1.11	0.45	2.70	0.42	0.12	1.53	
	Education - University degree	1.07	0.63	1.83	0.95	0.49	1.84	
Income - £5000 to £9999 per year	3.74	0.38	37.10	0.87	0.17	4.44		
Income - £10,000 to £14,999 per year	4.27	0.45	40.32	0.95	0.20	4.47		
Income - £15,000 to £19,999 per year	5.48	0.62	48.74	0.69	0.15	3.18		

Table 6 (continued)

		Image and performance user				Health and recovery user		
		Terms	OR	OR 2.5 %	OR 97.5 %	OR	OR 2.5 %	OR 97.5 %
Model 4	Income - £20,000 to £24,999 per year	2.27	0.25	20.20	0.75	0.19	3.01	
	Income - £25,000 to £29,999 per year	3.13	0.36	27.51	0.53	0.13	2.23	
	Income - £30,000 to £34,999 per year	8.83	1.05	74.20	0.20	0.03	1.21	
	Income - £35,000 to £39,999 per year	6.69	0.79	56.93	0.81	0.18	3.61	
	Income - £40,000 to £44,999 per year	2.98	0.30	29.89	0.60	0.12	2.84	
	Income - £45,000 to £49,999 per year	6.50	0.74	57.00	0.62	0.14	2.83	
	Income - £50,000 to £59,999 per year	8.88	1.03	76.12	0.58	0.14	2.49	
	Income - £60,000 to £69,999 per year	5.77	0.66	50.58	0.14	0.01	1.30	
	Income - £70,000 to £99,999 per year	6.07	0.66	55.72	0.57	0.12	2.76	
	Income - £100,000 and over	9.54	0.93	98.10	1.39	0.30	6.54	
	Mining extent	2.37	1.11	5.06	1.17	0.50	2.73	
	Age	1.02	1.00	1.05	0.99	0.96	1.02	
	Ethnicity - Mixed/ Multiple ethnic groups	0.60	0.10	3.50	1.05	0.18	6.15	
	Ethnicity - Asian/ Asian British/ Asian Welsh	0.20	0.03	1.57	0.66	0.15	2.91	
	Ethnicity - Black/ African/ Caribbean/Black British/Black Welsh	*	*	*	*	*	*	
Model 5	Ethnicity - Other Ethnic group	*	*	*	0.88	0.11	7.21	
	Conformity to masculine norms	1.08	1.04	1.12	1.02	0.98	1.06	
	Mining extent	2.13	1.03	4.42	1.15	0.49	2.70	
	Age	1.02	0.99	1.04	0.99	0.96	1.02	
	Ethnicity - Mixed/ Multiple ethnic groups	0.61	0.11	3.48	1.06	0.18	6.19	
	Ethnicity - Asian/ Asian British/ Asian Welsh	0.23	0.03	1.74	0.70	0.16	3.08	
	Ethnicity - Black/ African/ Caribbean/Black British/Black Welsh	*	*	*	*	*	*	
	Ethnicity - Other Ethnic group	*	*	*	0.92	0.11	7.50	
	Male Body Attitudes Scale - Muscularity	1.03	1.01	1.04	1.01	0.99	1.02	
	Mining extent	2.27	1.08	4.80	1.19	0.49	2.88	
Model 6	Age	1.02	1.00	1.05	0.99	0.96	1.02	
	Ethnicity - Mixed/ Multiple ethnic groups	0.77	0.13	4.70	1.00	0.16	6.16	

(continued on next page)

Table 6 (continued)

	Image and performance user				Health and recovery user		
	Terms	OR	OR 2.5 %	OR 97.5 %	OR	OR 2.5 %	OR 97.5 %
	Ethnicity - Black/Asian/White/British/Black British/Black Welsh	0.20	0.03	*1.55	0.63	0.13	3.01
	Ethnicity - Other	*	*	*	0.81	0.09	7.26
	Conformity to masculine norms	1.07	1.03	1.11	1.02	0.98	1.06
	Male Body Attitudes Scale - Muscularity	1.02	1.00	1.04	1.00	0.99	1.02
	Finances - Falling behind with some bills or credit commitments	0.61	0.25	1.51	0.35	0.11	1.17
	Finances - Keeping up but it's a constant struggle	0.36	0.16	0.81	0.46	0.18	1.16
	Finances - Keeping up but it's a struggle from time to time	0.48	0.22	1.06	0.46	0.19	1.12
	Finances - Keeping up with all bills and credit commitments without any difficulties	0.40	0.17	0.93	0.68	0.27	1.73
	Finances - Have no bills	0.44	0.11	1.81	0.31	0.05	1.80
	Finances - Prefer not to say	0.20	0.02	1.80	0.58	0.09	3.86
	Education - None	1.13	0.45	2.86	0.42	0.12	1.53
	Education - University degree	1.20	0.70	2.07	0.98	0.50	1.91
	Income - £5000 to £9999 per year	3.44	0.33	35.48	0.84	0.16	4.27
	Income - £10,000 to £14,999 per year	4.29	0.43	42.38	0.92	0.19	4.33
	Income - £15,000 to £19,999 per year	6.79	0.75	61.58	0.69	0.15	3.17
	Income - £20,000 to £24,999 per year	2.41	0.26	22.11	0.74	0.19	2.94
	Income - £25,000 to £29,999 per year	2.83	0.32	25.43	0.51	0.12	2.13
	Income - £30,000 to £34,999 per year	8.69	1.02	74.11	0.19	0.03	1.16
	Income - £35,000 to £39,999 per year	6.49	0.74	56.47	0.76	0.17	3.41
	Income - £40,000 to £44,999 per year	2.81	0.27	28.76	0.56	0.12	2.71
	Income - £45,000 to £49,999 per year	6.60	0.74	58.92	0.60	0.13	2.73
	Income - £50,000 to £59,999 per year	7.69	0.88	67.07	0.53	0.12	2.28
	Income - £60,000 to £69,999 per year	4.79	0.54	42.50	0.13	0.01	1.20

Table 6 (continued)

Image and performance user					Health and recovery user		
Terms	OR	OR	OR	OR	OR	OR	
		2.5 %	97.5 %		2.5 %	97.5 %	
Income - £70,000 to £99,999 per year	5.51	0.59	51.90	0.54	0.11	2.61	
Income - £100,000 and over	7.29	0.69	77.25	1.24	0.26	5.88	

scepticism of formal education (Esposito and Abramson, 2021), as well as differences in various facets of the 'big five' personality traits (Obschonka et al., 2018). Thus, even if there are not differences in muscularity concerns in coalfield and non-coalfield areas, those with high drive for muscularity may have different attitudes about how best to accomplish this muscularity.

Another possibility is that a different type of gender role measure might have yielded the hypothesised results. The conformity to masculine norms scale is a gender ideology measure, measuring agreement with a set of male-coded normative values (Luyt, 2005; Thompson et al., 1992). Potentially a measure of gender role conflict, measuring mismatch between one's ideal self and one's realised self, might have a different relationship with deindustrialisation and steroid use.

Furthermore, there has long been contention as to whether treating masculine norms as a single overarching gender ideology is a reasonable simplification (Thompson et al., 1992). The widely used concept of hegemonic masculinity refers to the 'most honored way of being a man' in a given context (Connell and Messerschmidt, 2005), recognising that this is subject to constant renegotiation by society, and varies across time and geography. Indeed the model we test perhaps implicitly treats steroid use as a way that men might renegotiate hegemonic masculinity when other paths to valorised masculinity – supporting a family through dangerous manual labour – are closed to them. This form of masculinity might fit into the concept of 'protest masculinity': a form of reactive masculinity seen in economically marginalised settings. While early views of 'protest masculinity', a form of masculinity seen in economically marginalised settings, were that it was an unambiguously hyper-masculine reaction to threats to male identity (Broude, 1990), more recent scholarship, including work based in Welsh coalfield communities (Gater, 2024), has added more nuance to this picture, suggesting that protest masculinities often include 'softer' or more feminised aspects alongside machismo.

Thus, potentially our measure was not able to capture this dynamic negotiation process, or the particular form of masculine ideology at play in these communities. That all said, the conformity to masculine norms scale was a strong predictor of steroid use, suggesting that there was at least broad conceptual overlap.

Alternatively, the growth in steroid use, may be due to supply side changes in the steroid market, rather than changes in demand. Work on the opioid crisis in the United States has proposed the supply-side drug environment as an alternative driver of the crisis to the demand-side 'deaths of despair' narrative (Ruhm, 2018), and potentially the growth of online availability and home production (Brennan et al., 2018) of steroids is a similar supply-side explanation. However, it is not clear that a purely supply-side account can explain the greater use of steroids in coalfield areas, and thus it is likely that the explanation for this is at least somewhat on the demand side.

Finally, it would be useful to look at the importance of social networks in spreading steroid-related norms. Social networks have been linked to the spread of a range of health behaviours (Christakis and Fowler, 2013) including steroid use (Woolf et al., 2014). Coalfield communities have a tradition of strong social ties, although survey work since the industry's decline have suggested that this may not apply today

Table 7

Coefficients for models measuring association between belong to each of the two classes of steroid users, image and performance users in the left-hand columns and health and recovery users in the right-hand column, and Conformity to Masculine Norms (terms in bold). Some terms for ethnicity groups ran from 0 to infinity due to low sample size in these groups.

Image and performance user					Health and recovery user		
Terms	OR	OR 2.5 %	OR 97.5 %		OR	OR 2.5 %	OR 97.5 %
Model 1	Conformity to masculine norms	1.06	1.03	1.10	1.02	0.98	1.06
Model 2	Conformity to masculine norms	1.07	1.04	1.11	1.02	0.98	1.06
	Age	1.02	1.00	1.05	0.99	0.96	1.02
	Ethnicity - Mixed/ Multiple ethnic groups	0.55	0.09	3.26	1.04	0.18	6.10
	Ethnicity - Asian/ Asian British/ Asian Welsh	0.18	0.02	1.38	0.64	0.15	2.81
	Ethnicity - Black/ African/ Caribbean/Black British/Black Welsh	*	*	*	*	*	*
	Ethnicity - Other Ethnic group	*	*	*	0.86	0.11	7.08
Model 3	Conformity to masculine norms	1.08	1.04	1.12	1.02	0.98	1.06
	Age	1.02	0.99	1.05	0.99	0.96	1.02
	Ethnicity - Mixed/ Multiple ethnic groups	0.66	0.11	4.07	0.98	0.16	6.01
	Ethnicity - Asian/ Asian British/ Asian Welsh	0.18	0.02	1.43	0.61	0.13	2.92
	Ethnicity - Black/ African/ Caribbean/Black British/Black Welsh	*	*	*	*	*	*
	Ethnicity - Other Ethnic group	*	*	*	0.80	0.09	7.08
	Finances - Falling behind with some bills or credit commitments	0.56	0.22	1.39	0.35	0.11	1.15
	Finances - Keeping up but it's a constant struggle	0.31	0.13	0.71	0.46	0.18	1.15
	Finances - Keeping up but it's a struggle from time to time	0.40	0.18	0.88	0.44	0.18	1.07
	Finances - Keeping up with all bills and credit commitments without any difficulties	0.32	0.14	0.74	0.65	0.26	1.64
	Finances - Have no bills	0.34	0.08	1.40	0.29	0.05	1.70
	Finances - Prefer not to say	0.15	0.02	1.32	0.56	0.09	3.61
	Education - None	1.17	0.46	2.97	0.43	0.12	1.54
	Education - University Degree	1.12	0.65	1.94	0.97	0.50	1.90
	Income - £5000 to £9999 per year	3.65	0.35	37.78	0.84	0.17	4.28
	Income - £10,000 to £14,999 per year	4.35	0.44	42.98	0.91	0.19	4.31

Table 7 (continued)

Image and performance user				Health and recovery user		
Terms	OR	OR 2.5 %	OR 97.5 %	OR	OR 2.5 %	OR 97.5 %
Income - £15,000 to £19,999 per year	6.77	0.74	61.77	0.70	0.15	3.19
Income - £20,000 to £24,999 per year	2.37	0.26	21.83	0.74	0.19	2.93
Income - £25,000 to £29,999 per year	2.89	0.32	26.37	0.51	0.12	2.13
Income - £30,000 to £34,999 per year	8.62	1.00	74.18	0.19	0.03	1.15
Income - £35,000 to £39,999 per year	6.16	0.70	54.23	0.76	0.17	3.38
Income - £40,000 to £44,999 per year	2.99	0.29	31.11	0.57	0.12	2.74
Income - £45,000 to £49,999 per year	6.68	0.73	60.72	0.60	0.13	2.74
Income - £50,000 to £59,999 per year	8.55	0.97	75.11	0.54	0.13	2.31
Income - £60,000 to £69,999 per year	5.14	0.57	46.00	0.13	0.01	1.22
Income - £70,000 to £99,999 per year	5.60	0.59	53.34	0.55	0.11	2.61
Income - £100,000 and over	7.92	0.74	84.68	1.26	0.27	5.96

(Abreu and Jones, 2021; Saville and Thomas, 2022). They do, however, have generally low residential turnover (Lansley et al., 2019), which may help to shape these networks in ways which may be important for the spread of health behaviours.

One of our reported analyses split users into two classes, based on the reasons they gave for steroid use – *image and performance* and *health and recovery*. We found that it was only image and performance use that was associated with coalfields and masculine norms. This seems compatible with the idea that exposure to deindustrialisation may be a driver of wanting to conform to the physical ideals of masculinity. However, as we discuss elsewhere, it is also plausible that the health and recovery group contained respondents who erroneously responded that they were steroid users and this explains the results. Other studies have carried out similar clustering analyses (Christiansen et al., 2017; Zahnnow et al., 2018). It is difficult to compare the clusters between studies, as different variables were used to construct them, but this approach seems a useful one to better understand the varying motivations and patterns of use across users, which could inform harm reduction and health messaging interventions.

The study had limitations which merit discussion. Firstly, one might argue that the themes identified by Keane (2005) are not a formal model of steroid use *per se*, and it would be more appropriate to test a model which has been proposed more explicitly (e.g. Bates et al., 2019). There is certainly some risk of creating a straw man model which no one is proposing. However, we would argue that there is value in examining the evidence for the sorts of informal discourses that are made around the drivers of the growth in steroid use, as well as testing formal models.

Secondly, surveying people about illicit behaviours like steroid use is challenging. Our headline prevalence (14.6 %) was high, compared to meta-analytic average prevalence estimates (6.4 % for men globally, Sagoe et al., 2014), but substantial heterogeneity exists across studies

and steroid use has grown in prevalence over time (McVeigh and Begley, 2017), and our findings were within the range. We were able to identify some participants whose free-text responses suggested that they were referring to corticosteroids, but not all respondents completed these free-text items so our final headline estimates may have still been inflated. Conversely, it is also plausible that some respondents did not admit to steroid use due to concerns around their legal status or the taboo around them. Furthermore, the participant information material made it clear that the survey would ask items about steroid use, so there was perhaps greater risk of survey fraud for these items, although other measures were in place to screen out such respondents. For the purpose of this paper, it is not clear why these issues would be more pronounced in coalfield areas (the topic of coalmining was not mentioned in participant information material), so we do not see these as particular issues for these findings. Indeed, one interpretation of the results of the latent class analysis is that respondents who were erroneously referring to corticosteroids or similar might be more likely to be classified as 'health and recovery' users, and the association between mining extent and the prevalence of 'image and performance' users but not 'health and recovery' users is because the latent class analysis better addressed these measurement issues.

Thirdly, while the model of steroid use we aim to test is causal, our data are cross-sectional. While reverse causation is probably not an issue here – modern steroid use clearly did not cause the decline of the Welsh mining industry – it is difficult to be confident that the greater use of steroids in former mining areas is not due to some other third variable, unaccounted for in our analyses.

Beyond the theoretical significance, increased steroid use in coalfield communities is an important public health issue. Steroid use has been linked to potential health risks and the fact that many steroid users are skeptical of the need for medical oversight (Bonnecaze et al., 2020) may mean that they are used at dangerous doses, that potential side effects are missed, or risks of blood-borne disease from injection are not well-managed (Hope et al., 2016). It may be that post-industrial communities need specific targeted interventions to reduce the potential harms linked to their use and future work on this topic may be warranted given the elevated use we see here.

To conclude, we examined conformity to masculine norms and local exposure to industrial decline as predictors of steroid use and male body image issues in Wales. The study is novel in quantitatively examining a plausible upstream structural determinant of steroid use by combining new survey data with geographical data. Our findings suggest that the elevated steroid use we find in coalfield areas is not mediated by thwarted masculinity. Our findings highlight steroid use as an emerging public health concern in deindustrialised areas, warranting further research into targeted harm reduction interventions.

CRedit authorship contribution statement

Christopher W.N. Saville: Writing – review & editing, Writing – original draft, Visualization, Software, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Ieuan Cranswick:** Writing – review & editing, Methodology, Conceptualization. **David Tod:** Writing – review & editing, Methodology, Conceptualization. **Dean Acreman:** Writing – review & editing. **Lee Hogan:** Writing – review & editing, Methodology, Conceptualization. **Daniel Rhys Thomas:** Writing – review & editing, Methodology, Conceptualization.

Conflict of interest

All authors declare that they have no conflicting interests.

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Data availability

Data will be available upon request, except detailed geographical data and some detailed demographic data, for reasons of disclosure prevention

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