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AMERICAN COLLEGE of RHEUMATOLOGY
Empowering Rheumatology Professionals

HEALTH DISPARITIES AND HEALTH EQUITY IN THE RHEUMATIC DISEASES

Do Patients With Intersectional Disadvantage Have Poorer Outcomes From Osteoarthritis Management Programs? A Tapered Balancing Study of Patient Outcomes From the Good Life With Osteoarthritis in Denmark Program

George Peat,[1] Dahai Yu,[2] Dorte T. Grønne,[3] Michelle Marshall,[2] Soren T. Skou,[4] and Ewa M. Roos[3]

Objective. To investigate whether adults with potential multiple social disadvantage have poorer outcomes following attendance in an osteoarthritis (OA) management program (OAMP), and if so, what might determine this result.

Methods. Among consecutive knee OA attendees of the Good Life With Osteoarthritis in Denmark (GLA:D) OAMP in Denmark we defined a group with potential "intersectional disadvantage" based on self-reported educational attainment, country of birth, and citizenship. Outcomes of this group were compared with GLA:D participants who were native Danish citizens with higher educational attainment. Outcomes were pain intensity, Knee Injury and Osteoarthritis Outcome Score (KOOS) quality of life subscale score, and the EuroQol 5-domain instrument in 5 levels (EQ-5D-5L) score at 3 and 12 months. After data preprocessing, we used entropy balancing to sequentially control for differences between the groups in baseline covariates. Mean between-group differences in outcomes were estimated by weighted linear regression.

Results. Of 18,448 eligible participants, 250 (1.4%) were nonnative/foreign citizens with lower education. After balancing for differences in baseline score and in administrative and demographic characteristics, they had poorer outcomes than higher-educated native Danish citizens on pain intensity and EQ-5D-5L score at both follow-up points (e.g., between-group mean differences in pain visual analog scale [0–100] at 3 and 12 months: 3.4 [95% confidence interval (95% CI) –0.5, 7.3] and 6.2 [95% CI 1.7, 10.7], respectively). Differences in KOOS quality of life subscale score, were smaller or absent. Balancing for differences on baseline score, comorbidity, self-efficacy, and depression had the greatest effect on reducing observed outcome inequalities.

Conclusion. Outcome inequalities widened following OAMP attendance, particularly at longer-term follow-up, but the magnitude of differences was generally modest and inconsistent across outcome measures. Tailoring content to reduce outcome inequalities may be indicated, but improving access appears the greater priority.

INTRODUCTION

Osteoarthritis (OA) is a condition that affects over 500 million adults worldwide, accounting for 2.2% of years lived with disability (1). It is associated with a range of significant impacts on work productivity, work loss, premature retirement, and direct and indirect costs. In common with many chronic noncommunicable diseases, the occurrence, severity, and impact of OA tends to be greater among disadvantaged and marginalized people and communities, prompting calls for greater attention to equity-focused

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SIGNIFICANCE & INNOVATIONS

- In a growing number of countries, osteoarthritis management programs (OAMPs) play an important role in providing core recommended care and supported self-management. There is emerging evidence of social inequalities in access to OAMPs but less on whether inequalities in outcomes are widened or narrowed among those attending an OAMP ("intervention-generated inequalities").
- Analyzing real-world observational outcomes at 3 and 12 months from the Good Life With Osteoarthritis in Denmark OAMP, we found that inequalities in patient-reported health outcomes widened between participants with potential intersectional disadvantage (defined by education level, country of birth, and citizenship) and participants who were native Danish citizens with higher education.
- OAMPs may need to tailor their content to prevent participants from potentially disadvantaged social backgrounds losing further ground. Strategies to help maintain short-term gains among those with lower self-efficacy and mood and with more comorbidities may be useful. Improving accessibility of OAMPs to socially disadvantaged individuals and communities should be the greater priority.

research and policies (2,3). A common concern is whether recommended health care interventions, services, and models of care inadvertently widen inequalities in health outcomes (so-called "intervention generated inequalities"). This increase in inequality could arise from inequalities at multiple points in the provision, uptake, and response to interventions (4,5), and from patient preferences and safety considerations (6). The potential for such inequality appears greater for downstream interventions that target individual behavior change (7), that require high levels of personal agency (8), and that are accessed through self-referral (9).

Effective low-cost interventions that support self-management are a critical component of how health and care systems respond to the challenge of OA. Osteoarthritis management programs (OAMPs) have emerged in the past decade in a major international effort to address consistent evidence of suboptimal provision of core recommended nonsurgical care (10). People from socially disadvantaged backgrounds may be less likely to access these programs (11), but there is little evidence on outcome inequalities among patients gaining access to OAMPs. The ideal source of evidence (theoretically informed, adequately powered, and appropriately conducted and reported prespecified subgroup analyses of randomized controlled trials [RCTs]) requires very large RCTs or pooling of suitably harmonized data from multiple trials of comparable OAMPs. The difficulties in assembling such RCT evidence are substantial. In such circumstances, inferences rely more heavily on available observational data that may also better reflect real-world outcomes. In this study we applied a modified version of tapered matching analysis from Silber et al (12) to data on patient outcomes following attendance in the Good Life with Osteoarthritis in Denmark (GLA:D) OAMP.

Our research question was whether people with knee OA and multiple, intersecting social disadvantages attending GLA:D have poorer outcomes than their counterparts with multiple advantages? If so, what might determine this difference? For our study, we focused on the relative outcomes of participants with low educational attainment who were additionally either born outside Denmark or were not Danish citizens. Lower educational level is a key dimension for monitoring health inequalities, is associated with poorer health-related quality of life at most ages in Denmark (13), and has been associated with modest differences in outcome in the Better Management of Patients with Osteoarthritis OAMP in Sweden (14) and the GLA:D program in Denmark (15,16). Migrant status and ethnicity have been persuasively argued as important social determinants of health, in Denmark and beyond (17,18). They are not directly recorded in GLA:D, but country of birth and citizenship may be useful proxies. People of Danish origin constitute 86% of the total population, with the next largest group being immigrants from non-Western countries (6.1%) and their descendants (2.7%).

MATERIALS AND METHODS

Study setting and population. Our study was an analysis of prospectively collected, observational data from the national GLA:D registry. GLA:D is a national, nonprofit initiative hosted at the University of Southern Denmark with the purpose of implementing clinical guidelines for adults with knee or hip OA in the Danish population. Since January 2013, patients with knee and hip OA symptoms could be referred by a health care professional or by self-referral to an 8-week program comprising 2–3 patient education sessions and 12 clinician-supervised exercise therapy sessions, delivered by a trained physical therapist, mainly in primary care centers and municipal settings. Currently, roughly 1 in 3 municipalities in Denmark offers exercise and education for their citizens (i.e., for free for the patient).

Participants may access the GLA:D program in 3 ways: general practitioner referral (approximately 40% of treatment cost is reimbursed), self-referral (treatment cost is not reimbursed), or referral to their municipality by an orthopedic surgeon (full treatment cost is reimbursed). The GLA:D program builds on extensive evidence supporting the central role and effectiveness of exercise therapy for knee OA (19). A full description of the GLA:D program and outcomes is provided elsewhere (20). More than 1,500 physical therapists in Denmark have completed the training and the program is currently being implemented in Canada, Australia, China, Switzerland, New Zealand, Austria, Ireland, and Germany, with new countries joining each year (www.gladinternational.org).

The Danish national, electronic GLA:D registry houses data on participant characteristics and outcomes collected at baseline, 3 months, and 12 months via a combination of patient-reported, therapist-reported, and objective measures, and the routine collection of standard outcomes is an integral component of the GLA:D program. The GLA:D registry was approved by the Danish Data Protection Agency, and according to the Danish Data Protection Act, patient consent was not required, as personal data were processed exclusively for research and statistical purposes. Separate ethics approval was not needed for the current analysis.

The current analysis specifically selected consecutive participants enrolled in the GLA:D program in Denmark between October 9, 2014 and February 28, 2018, the period during which the outcome measures, exposures, and covariates of interest in this analysis were included in the data collection instruments. All participants who returned a baseline patient-reported questionnaire between these dates, indicated that their main problem (index joint) was the knee, and completed at least 1 of the social stratifiers used to define the focal group of interest, were eligible for inclusion in our analyses. For participants taking the program more than once, only the index attendance was included in the analysis. Baseline measurements were completed prior to commencing the intervention, typically within the prior 2 weeks.

Defining "intersectional disadvantage" and "intersectional advantage" groups of interest. Drawing on the PROGRESS-Plus acronym framework (place of residence, race/ethnicity/culture/language, occupation, gender/sex, religion, education, socioeconomic status, and social capital) (21), we focused on the intersection of 3 social stratifiers available within the GLA:D registry that we used to define disadvantage: educational level, place of birth, and citizenship. We defined intersectional disadvantage as having only mandatory primary/secondary school education and either not being born in Denmark or not having Danish citizenship. The comparator group with intersectional advantage were native Danish citizens with higher (postsecondary) education.

Outcomes of interest. We chose 3 patient-reported outcomes representing related but distinct domains relevant to patients and the health care system (22), each measured with instruments previously recommended and validated for evaluating outcomes in OA (23–25), and completed at baseline, postintervention (3 months after baseline), and at 12 months.

Mean pain intensity during the last month in the most affected joint was evaluated on a 100-mm visual analog scale (VAS) anchored by no pain (0 mm) and maximum pain (100 mm). Joint-related quality of life was evaluated using the Knee Injury and Osteoarthritis Outcome Score (KOOS) quality of life (QoL) subscale (http://www.koos.nu/). Scores range from 0 (worst) to 100 (best). Generic health-related quality of life was assessed using the EuroQol 5-domain instrument in 5 levels (EQ-5D-5L) utility score (euroqol.org). Scores range from <0 (representing health states worse than dead) to 1.0 (full health) (26).

Covariates. We used the following covariates in our analysis to capture potentially important prognostic factors (27,28): age (years), sex, type of treatment center (public/private), calendar year of baseline assessment, body mass index (kg/m^2), previous knee injury, previous knee surgery, number of selected self-reported comorbidities (high blood pressure, heart disease, chronic respiratory disease, diabetes mellitus, gastric ulcer/other gastric disease, kidney or liver disease, anemia or other blood disorder, cancer, rheumatoid arthritis, and neurologic disorders; categorized as 0, 1, 2, 3+), number of other nonknee pain sites from full body mannikin (0–52), Arthritis Self-Efficacy Scale (29) pain subscale score (10–100), self-reported presence of depression, current/previous receipt of tailored exercise advice, weight loss counseling, analgesia or natural remedies, attendance at GLA:D program initiation and education sessions (attended >3 sessions), and attendance at GLA:D exercise sessions (attended >9 sessions).

Data analysis and statistics. *Preprocessing.* Prior to tapered balancing, to reduce model dependence (30) and the potential for irresolvable imbalances between the 2 groups, we used coarsened exact matching (31) to restrict the comparison of exposed and nonexposed patients to areas of common support, i.e., sufficient overlap between the 2 groups, on key prognostic factors (age, sex, body mass index, baseline value of the outcome measure of interest), coarsened using the default Sturges measure of bin size (32). After excluding patients who were off common support, we then used entropy balancing (33,34) to efficiently minimize differences in the distribution of covariates between the 2 groups of patients. Entropy balancing involves maximum entropy reweighting of the "higher formal education, native Danish citizen" group by directly incorporating covariate balance into the weight function. We followed a similar approach to Silber et al (12) and balanced on a progressive number of covariates. Since we were concerned with whether inequalities widened following attendance on the GLA:D program, our first step was to control for differences in baseline values of the outcome.

Subsequent steps were organized a priori in what we felt were logical groupings and order: 1) baseline values of the outcomes of interest, 2) administrative (type of treatment center and calendar year, i.e., whether differences are explained by the type of treatment center and whether participants belonged to early or later adopters), 3 demographic characteristics (age, sex), 4) OA risk/prognostic factors (body mass index, previous knee injury, previous knee surgery), 5) comorbidities (number of selected comorbidities, number of other nonknee pain sites), 6) psychological factors (self-efficacy, self-reported presence of depression), 7) previous/current nonsurgical treatment (tailored exercise advice, weight loss counseling, analgesia/natural remedies), and 8) attendance at GLA:D initiation/education and exercise sessions. Each of the steps above addressed a specific question on the possible reasons for differences in outcomes between the 2 groups of patients. For example, steps 1–3 estimate whether observed differences in outcomes at 3 and 12 months between the 2 groups of patients remain after controlling for differences in baseline score and key confounders of age, sex, year of treatment, and setting. Steps after this point consider the role of other determinants. For example, step 8 considers whether, having accounted for differences in all of the observed covariates in steps 1–7, any remaining difference in outcomes is reduced once controlling for the level of attendance at GLA:D sessions. To maximize the control of covariates, all continuous covariates were balanced for mean, variance, and skewness. We explored the resultant weights at each step for unusual patients allocated exceptionally high weights and exerting undue influence. An illustrative example of covariate balance before and after reweighting is given in Supplementary Table 1, available on the *Arthritis Care & Research* website at http://onlinelibrary.wiley.com/doi/10.1002/acr.24987.

Estimation. Between-group mean differences in outcomes at 3 and 12 months (pain VAS, KOOS Quality of Life subscale score, and EQ-5D-5L utility score) were estimated by linear regression without balancing (i.e., crude difference) and then with the entropy balancing weights from each step (steps 1–8), representing successively tighter control of differences in covariate distributions between the 2 groups being compared. We analyzed 3- and 12-month outcomes in separate regression models in an attempt to methodically explore differences in short-term and longer-term outcome inequalities.

Multiple imputation of missing data. Data on each of the exposures and covariates were missing in fewer than 1% of eligible participants, but outcomes at 3 and 12 months were missing in 24–25% and 38–39% of participants, respectively, and were higher among nonnative/foreign citizens with lower education (see Supplementary Table 2, available on the *Arthritis Care & Research* website at http://onlinelibrary.wiley.com/doi/10.1002/acr.24987). In these circumstances, imputation may be useful (35). Based on a worst case scenario of 56% of participants with 1 or more missing exposure, covariate, or outcome datapoint, we created 56 imputed data sets using multiple imputation with chained equations. Separate imputation models were constructed for each of the 3 outcomes (pain VAS, KOOS QoL, and EQ-5D-5L). Imputation models included values for outcome measures at baseline, 3 months, and 12 months, all covariates used in preprocessing and an auxiliary variable (employment status at baseline). Subsequent analyses applied all preprocessing and estimation within each imputed data set before combining estimates using Rubin's rules (36,37). Analyses were implemented using off-the-shelf packages in Stata, version 14.2.

Table 1. Descriptive characteristics of GLA:D participants, by group*

Characteristic	Nonnative/foreign citizens with lower education (n = 250)†	Native Danish citizens with higher education (n = 12,493)‡
Age, mean ± SD years	61.6 ± 10.7	64.0 ± 9.4
Female	180 (72)	9,224 (74)
Year of attendance		
2014	9 (4)	409 (3)
2015	41 (16)	2,852 (23)
2016	103 (41)	4,165 (33)
2017	79 (32)	4,233 (34)
2018	18 (7)	834 (6)
Treatment center type: private	158 (63)	10,577 (85)
Postsecondary education	0 (0)	12,493 (100)
Not born in Denmark	241 (96)	0 (0)
Not Danish citizen	101 (41)	0 (0)
Employed/student	55 (22)	4,400 (35)
Body mass index, mean ± SD kg/m^2	29.2 ± 5.1	28.5 ± 5.4
Previous injury	116 (47)	6,803 (55)
Previous surgery	61 (24)	3,752 (30)
No. of nonknee pain sites, mean ± SD	3.1 ± 4.5	1.9 ± 2.9
Self-reported comorbidities		
0	98 (40)	6,020 (48)
1	92 (37)	4,412 (35)
2	41 (17)	1,538 (12)
3–10	15 (6)	502 (4)
Self-reported depression	39 (16)	490 (4)
Arthritis Self-Efficacy Scale: mean ± SD baseline pain (10–100)	57.3 ± 21.6	68.0 ± 19.5
Previously received tailored exercise advice	78 (31)	4,311 (35)
Previously received weight loss counseling§	136 (54)	7,231 (58)
Currently take pain medications, herbal or dietary supplements	192 (77)	9,349 (75)
High attendance on GLA:D initiation and education sessions¶	116 (71)	6,431 (78)
High attendance on GLA:D exercise sessions#	123 (74)	6,822 (83)

* Values are the number (%) unless indicated otherwise. All values are based on observed data before multiple imputation. GLA:D = Good Life With Osteoarthritis in Denmark.
† Defined as having only mandatory primary/secondary school education and either not being born in Denmark or not having Danish citizenship.
‡ Defined as native Danish citizens with higher (postsecondary) education.
§ Respondents who indicated “yes” or “not relevant.”
¶ >3 sessions.
# >9 sessions.

RESULTS

Between October 9, 2014 and February 28, 2018, 18,448 consecutive adults enrolled in the GLA:D program and were eligible for inclusion in our analysis. A total of 250 (1.4%) were nonnative/foreign citizens with lower formal education, and 12,493 (67.7%) were native Danish citizens with higher formal education. Compared to the latter group, the former were younger, less likely to have attended GLA:D in a private physical therapy clinic, reported more comorbidity, pain sites, and depression, and lower self-efficacy, and they attended fewer GLA:D sessions (Table 1 and Supplementary Table 3, available on the *Arthritis Care & Research* website at http://onlinelibrary.wiley.com/doi/10.1002/acr.24987).

Relative outcomes of nonnative/foreign citizens with lower formal education. Based on multiply imputed data, improvements in group mean scores for all 3 outcomes were seen at 3 months in both groups, with levels generally maintained at 12 months (Table 2). After excluding patients who were off common support, tapered balanced analyses compared the pain VAS, KOOS QoL, and EQ-5D-5L outcomes of 228, 236, and 225 nonnative/foreign citizens with lower formal education against 3,118, 4,714, and 5,969 native Danish citizens with higher formal education, respectively, for each outcome. Without any balancing, the nonnative/foreign citizens with lower formal education group had pain VAS scores that at 3 months were, on average, 5.98 points higher (95% confidence interval [95% CI] 2.57, 9.38), i.e., worse, than the native Danish citizens with higher formal education group. At 12 months, this crude between-group mean difference was 8.57 (95% CI 4.52, 12.61). After balancing for baseline differences in pain VAS, these between-group mean differences in pain VAS outcomes at 3 and 12 months reduced to 3.76 (95% CI 0.01, 7.54) and 6.75 (95% CI 2.41, 11.08), respectively. Further reductions in the between-group mean differences were seen after balancing for comorbidities (step 5) and

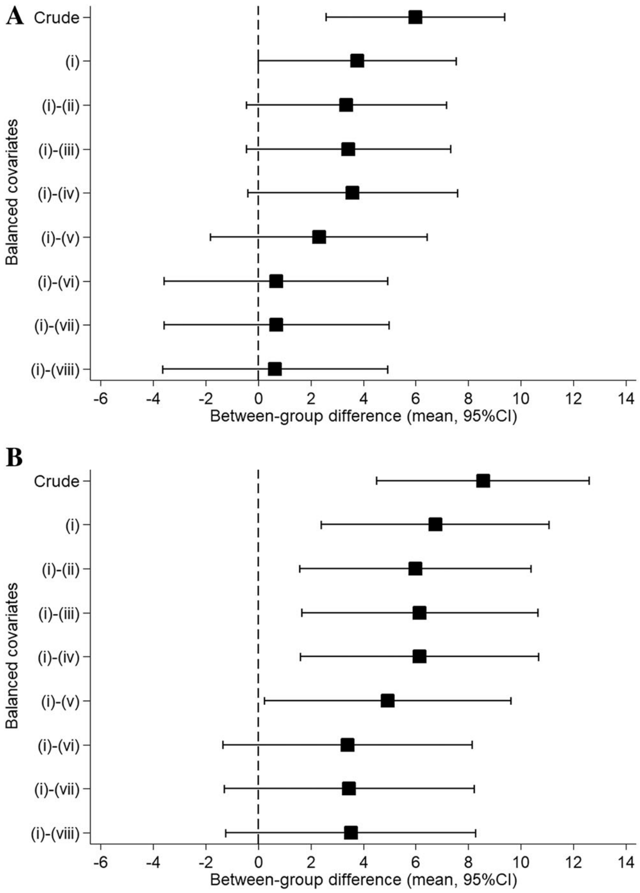

Figure 1. Mean between-group difference (95% confidence interval [95% CI]) in outcomes for nonnative/foreign citizens with lower education versus native Danish citizens with higher education. **A**, Pain visual analog scale (VAS; 0–100) at 3 months. **B**, Pain VAS (0–100) at 12 months. Positive values indicate poorer outcomes among nonnative/foreign citizens with lower education relative to the native Danish citizens with higher education group.

Table 2. Descriptive outcomes, by group*

Outcome	Nonnative/foreign citizens with lower education (n = 250)†	Native Danish citizens with higher education (n = 12,493)‡
Pain VAS (0–100)		
Baseline	56.8 (53.7, 59.9)	46.8 (46.4, 47.1)
3 months	42.6 (39.2, 46.0)	34.0 (33.6, 34.4)
12 months	44.8 (40.7, 48.9)	34.1 (33.6, 34.6)
KOOS QoL score (0–100)		
Baseline	40.0 (38.0, 42.1)	45.2 (45.0, 45.5)
3 months	47.3 (44.8, 49.7)	51.0 (50.7, 51.3)
12 months	48.0 (45.0, 51.1)	54.1 (53.7, 54.5)
EQ-5D-5L score (range −0.624 to 1)		
Baseline	0.644 (0.622, 0.665)	0.718 (0.716, 0.719)
3 months	0.679 (0.659, 0.699)	0.755 (0.753, 0.757)
12 months	0.681 (0.659, 0.702)	0.755 (0.753, 0.758)

* Values are the mean (95% confidence interval). Based on multiply imputed data. EQ-5D-5L = EuroQol 5-domain instrument in 5 levels; KOOS = Knee Injury and Osteoarthritis Outcome Score; QoL = quality of life; VAS = visual analog scale.
† Defined as having only mandatory primary/secondary school education and either not being born in Denmark or not having Danish citizenship.
‡ Defined as native Danish citizens with higher (postsecondary) education.

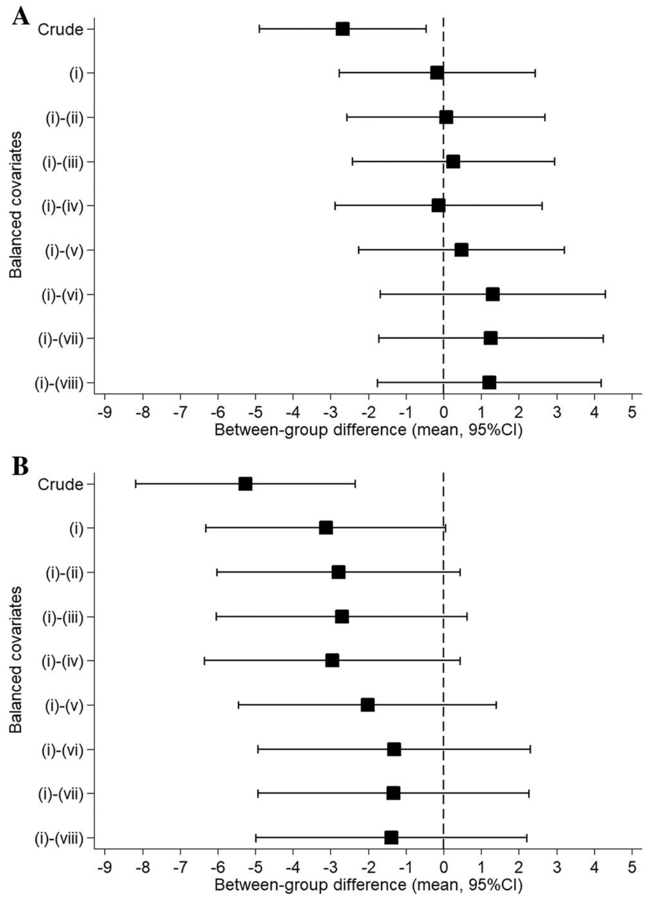

Figure 2. Mean between-group difference (95% confidence interval [95% CI]) in outcomes for nonnative/foreign citizens with lower education versus native Danish citizens with higher education. **A**, Knee Injury and Osteoarthritis Outcome Score (KOOS) quality of life (QoL; 0–100) at 3 months. **B**, KOOS QoL (0–100) at 12 months. Negative values indicate poorer outcomes among nonnative/foreign citizens with lower education relative to the native Danish citizens with higher education group.

self-efficacy and depression (step 6). Balancing for other covariates had little effect. After balancing on all covariates, the between-group mean differences in pain VAS outcomes at 3 and 12 months were 0.65 (95% CI –3.64, 4.93) and 3.53 (95% CI –1.23, 8.28), respectively (Figure 1 and Supplementary Table 4, available on the *Arthritis Care & Research* website at http://onlinelibrary.wiley.com/doi/10.1002/acr.24987).

A similar pattern of findings was seen for EQ-5D-5L scores, although between-group differences on KOOS QoL, particularly at 3 months, were very small. Crude between-group differences in these outcomes were, like pain VAS, greater at 12 months than at 3 months, and balancing for differences on baseline score, comorbidity, self-efficacy, and self-reported depression had the greatest effect on estimates (Figures 2 and 3). After balancing on all covariates, the between-group mean differences at 3 and 12 months for KOOS QoL were 1.22 (95% CI –1.75, 4.18) and –1.39 (95% CI –4.99, 2.21) and for EQ-5D-5L score were –0.022 (95% CI –0.042, –0.002) and –0.025 (95% CI –0.049, 0.000), respectively (see Supplementary Tables 5 and 6, available on the *Arthritis Care & Research* website at http://onlinelibrary.wiley.com/doi/10.1002/acr.24987).

DISCUSSION

Adults who were nonnative or foreign citizens with lower levels of formal education who accessed a recommended, national OAMP with knee OA reported improvements in knee pain intensity, knee-related quality of life, and general health status postintervention. Improvements were typically maintained at 12 months of follow-up. However, the absolute levels of such participants on all 3 outcomes at 12 months were worse than those of participants who were native Danish citizens with higher levels of formal education. Nonnative/foreign citizens with lower formal education who accessed the program began the OAMP with

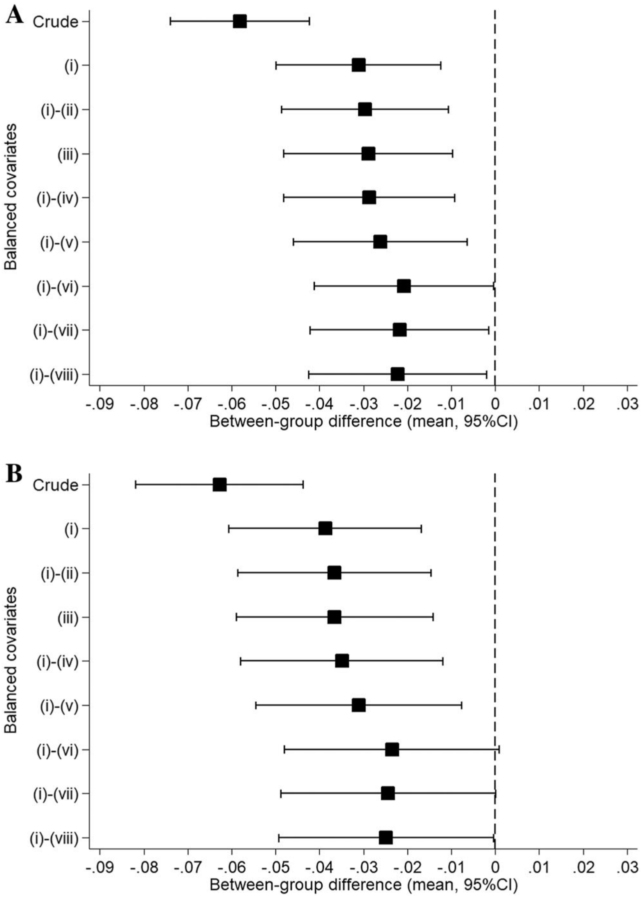

Figure 3. Mean between-group difference (95% confidence interval [95% CI]) in outcomes for nonnative/foreign citizens with lower education versus native Danish citizens with higher education. **A**, EuroQol 5-domain instrument (EQ5D; –0.624 to 1) at 3 months. **B**, EQ5D (range –0.624 to 1) at 12 months. Negative values indicate poorer outcomes among nonnative/foreign citizens with lower education relative to the native Danish citizens with higher education group.

more severe pain and poorer quality of life. Inequalities in pain, disability, and quality of life outcomes persisted after controlling for these baseline differences and potential administrative and demographic confounders, meaning that the inequality gap widened slightly following attendance in GLA:D. The magnitude of this gap differed across outcome measures. Taking the most extreme example, 12-month outcomes in nonnative/foreign citizens with lower formal education were, on average, 6 points worse on 0–100 pain VAS, 2 points worse on 0–100 KOOS QoL score, and 0.03 points worse on EQ-5D-5L index score, compared to higher educated, native Danish citizens, after adjusting for baseline score, treatment setting, year of attendance, age, and sex. Differences between the groups in baseline levels of self-efficacy, depression, and other comorbidities appeared to contribute to these inequalities in outcome.

Previous single-arm regression analyses of observational data from GLA:D and Better Management of Patients with Osteoarthritis OAMPs have reported small differences of questionable clinical importance in pain intensity outcomes related to educational level (14–16). The differences found in our study of "intersectional disadvantage" (education and country of birth/citizenship) were somewhat greater and consistently in favor of native Danish citizens with higher formal education, although this finding appeared to vary by outcome. None of these studies, including our own, observed outcomes from a comparable patient group under a control condition, e.g., no treatment. We therefore cannot know whether the inequality gap in outcomes would have been greater in the absence of attending the OAMP. Rigorous subgroup analyses of RCT data may provide the best available evidence of differential effectiveness of interventions. However, the challenges in obtaining such evidence, particularly for equity-focused analyses, are well-recognized (38) and to our knowledge are not available from trials of OAMP or exercise trials in OA.

In low back pain, a recent individual patient data meta-analysis of RCTs of exercise therapy found better pain outcomes at 3 and 12 months in patients with greater than high school education compared to those with education up to high school only (3 months: 12 trials, adjusted mean difference [range 0–100] −3.69 [95% CI −8.65, 1.27]; 12 months: 5 trials, −13.36 [95% CI −23.60, −3.12]) (39). This finding suggests the potential for important intervention-generated inequalities from nonpharmacologic treatment for a common musculoskeletal pain condition. However, we should be wary of generalizing findings from educational level to other forms of multiple social disadvantage and from exercise therapy for low back pain to OAMPs for knee OA.

Reduced access and engagement among lower socioeconomic groups has been previously highlighted in OAMPs (11) and in chronic disease self-management programs (9). The focus of our study was on outcome inequalities, although we note that only 1 in 75 participants was a nonnative/foreign citizen with lower formal education and that loss to follow-up was higher in this group. Baseline levels of pain and quality of life were worse among nonnative/foreign citizens with lower formal education. A previous single-center study in Denmark showed similar inequalities in preoperative levels of pain, disability, and quality of life among patients undergoing total knee arthroplasty (40). Our findings imply that such inequalities apply to nonsurgical management earlier in the care pathway.

Our study used data from a large nationwide registry in Denmark covering consecutive patients receiving a standardized intervention and featuring collection of a wide range of measures, including recommended valid outcome measures. Rates of missing data at baseline were minimal, but loss to follow-up will mean that findings, particularly on 12-month outcomes, will be sensitive to any misspecification of our imputation model. Data were assumed to be missing at random, but missingness may be related to unobserved factors. We did not conduct further sensitivity analyses. Our study is limited to patient-reported outcomes. Some performance-based measures were collected by the physical therapist at 3 months but not at 12 months. Our decision to separately model 3- and 12-month outcomes ignores the nonindependence of repeated outcomes and risks a suboptimal model fit. Future similar applications should seek to combine tapered entropy balancing with mixed-model repeated measures methods.

It was important to move beyond univariable definitions of social disadvantage, and we chose to define potential intersectional disadvantage using available information on educational level, country of birth, and citizenship. This combination, together with our choice of comparison group of native, Danish citizens with high levels of education, effectively created a contrast of extremes. Downsides of this choice were the need to dichotomize educational level and imprecise estimates, given the relatively small number of participants in this focal group (<250). As the size of the registry data set grows, and pooling of data across registries becomes possible (41), this limitation will recede. Country of birth and citizenship status are relatively crude approaches to characterizing disadvantage. The combined effect of eligibility criteria and misclassification would be to bias our estimates of inequalities toward the null. Our approach to defining disadvantage is just one of several options. Data on other measures of social stratifiers, such as migrant status, ethnicity, income, or area-level deprivation, were not available within the data set. Employment status was used for description and as an auxiliary variable in the imputation model, although the proportion in employment at the time of baseline assessment did not differ markedly between the 2 groups. Extending our approach to other measures of individual socioeconomic position could be valuable.

We used coarsened exact matching to ensure common support, entropy balancing to efficiently control for covariates, including those with nonlinear distributions, and a prespecified sequence of balancing steps to evaluate potential determinants of observed outcome inequalities. All preprocessing was performed without reference to outcomes, in keeping with the belief that "the lack of availability of outcome data when designing experiments is a tremendous stimulus for honesty" (42). Exclusion of those participants off common support was limited to selected key covariates determined in advance. Our analysis made no allowance for clustering due to group effects, and estimates from entropy balancing may be overly precise, although weights were generally not large. We analyzed outcome values adjusted for baseline values rather than change scores, the latter being susceptible to bias when exposure is strongly associated with the baseline value (43). We chose not to adjust 12-month outcomes for outcomes at 3 months. Instead, widening inequalities between 3 and 12 months can be inferred from our models.

Caution is needed when generalizing our findings to other OAMPs. Health inequalities found among participants in an OAMP are likely to reflect in part underlying inequalities in the population. Denmark has had one of the lowest levels of income inequality in the world (44), above the Organization for Economic Co-operation and Development average rates of postsecondary educational attainment among adults (45), and relatively positive attitudes in its population to integration of immigrants (46), although immigration to Denmark, especially asylum seeking, has fallen since 2015. Data collected in GLA:D do not permit a distinction between immigrants and asylum seekers or when those individuals arrived in Denmark. Our sample was unlikely to include many recent asylum seekers; being unable to read and understand Danish is an exclusion criterion for GLA:D in Denmark. We would encourage similar analyses of suitable OAMP registry data in other countries.

Policymakers need better evidence on what does and does not work to reduce health inequalities among the large, and growing, number of people with OA. Equity-focused analyses of observational data from the large-scale roll-out of OAMPs internationally can contribute to this effort, but the collection and analysis of relevant measures of social determinants of health may need to be strengthened to enable this. We found that inequalities in health outcomes widened following OAMP attendance, but differences tended to be modest in size and varied by outcome measure, although the differences appeared greater at longer-term follow-up. The between-group differences we observed were much smaller than the main effects of exercise interventions for knee OA (19). The conclusion from a previous review of chronic disease self-management support interventions may be relevant, that "without careful tailoring and direct targeting of barriers to self-management, self-management support may exacerbate the social gradient in chronic disease outcomes" (9).

Our findings direct attention toward strategies to help adults from socially disadvantaged backgrounds with lower self-efficacy and mood and more comorbidities to maintain short-term gains. Our findings, however, also suggest other pressing priorities for narrowing outcome inequalities. Adults from socially disadvantaged backgrounds remain underrepresented among OAMP attendees. Improving equitable access and participation should be added to international priorities for OAMPs (47). Finally, large inequalities in pain and quality of life seen prior to commencing an OAMP are a reminder of the broader need for coordinated equity-focused public health actions earlier in the life course.

AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be submitted for publication. Dr. Peat had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. Peat, Yu.

Acquisition of data. Grønne, Skou, Roos.

Analysis and interpretation of data. Peat, Yu, Grønne, Marshall, Skou, Roos.

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