

## Usage of guideline-adherent core treatments for knee osteoarthritis before and after consulting an orthopaedic surgeon: A prospective cohort study



Simon Majormoen Bruhn<sup>a</sup>, Søren T. Skou<sup>b,c</sup>, Lasse Kindler Harris<sup>a</sup>, Thomas Bandholm<sup>d,e,f,g</sup>, Anne Møller<sup>h</sup>, Henrik M. Schrøder<sup>i,j</sup>, Anders Troelsen<sup>a</sup>, Lina Holm Ingelsrud<sup>a,\*</sup>

<sup>a</sup> Clinical Orthopaedic Research Hvidovre (CORH), Department of Orthopaedic Surgery, Copenhagen University Hospital—Hvidovre, Denmark

<sup>b</sup> Research Unit for Musculoskeletal Function and Physiotherapy, Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark

<sup>c</sup> The Research Unit PROgrez, Department of Physiotherapy and Occupational Therapy, Næstved-Slagelse-Ringsted Hospitals, Region Zealand, Denmark

<sup>d</sup> Department of Orthopaedic Surgery, Copenhagen University Hospital—Hvidovre, Denmark

<sup>e</sup> Physical Medicine & Rehabilitation Research Copenhagen (PMR-C), Department of Physical and Occupational Therapy, Copenhagen University Hospital—Hvidovre, Denmark

<sup>f</sup> Department of Clinical Research, Copenhagen University Hospital—Hvidovre, Denmark

<sup>g</sup> Department of Clinical Medicine, University of Copenhagen, Copenhagen, Denmark

<sup>h</sup> Center for Research and Education in General Practice, Department of Public Health, University of Copenhagen, Copenhagen, Denmark

<sup>i</sup> Department of Regional Health Research, University of Southern Denmark, Odense, Denmark

<sup>j</sup> Department of Orthopaedic Surgery, Næstved-Slagelse-Ringsted Hospitals, Region Zealand, Denmark

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### ABSTRACT

**Objective:** To describe 1) the proportion of patients with knee osteoarthritis (OA) undergoing guideline-adherent core treatments until six months after primary referral to an orthopaedic surgeon, 2) which specific treatment pathways these patients undertake and 3) the characteristics of patients choosing different treatment pathways. **Design:** This prospective cohort study consecutively invited patients referred to an orthopaedic surgeon due to knee OA at two Danish hospitals from October 2018 to December 2020. Before and six months after consulting the surgeon, patients answered a questionnaire reporting which treatments they had received for knee OA. The proportion receiving the combination of guideline-adherent treatments (i.e., exercise, education, and dietary weight management if needed) was determined. We evaluated the specific treatment usage before and until six months after the consultation and investigated characteristics of patients undertaking different pathways. **Results:** Out of 5251 eligible patients, 2574 (49%) had complete data and were included in analyses. 23% received guideline-adherent treatments, 10% had no treatment. Patients underwent 1143 unique treatment pathways, 62% including treatments not recommended/recommended against. Those who underwent guideline-adherent pathways had similar characteristics to those who did not but tended to be females, retired, had longer-lasting knee problems, have comorbidities, and higher education levels. **Conclusions:** Only one in four patients with knee OA received treatment adhering to clinical guidelines before and six months after consulting the surgeon. Patients used many different treatment pathways. There is a need for a structured effort to increase the use of guideline-adherent core treatments. **Trial Identifiers:** Registration: [NCT03746184](https://clinicaltrials.gov/ct2/show/study/NCT03746184), Protocol: PMID: 34233992.

## 1. Introduction

International clinical guidelines on the management of knee osteoarthritis (OA) recommend patient education, exercise and dietary weight

management, if overweight, as non-surgical first-line core treatments [1–4]. These treatments are considered to be effective, safe, and of low-cost [5]. When non-surgical first-line core treatments do not result in sufficient pain relief and improvement in functional ability, additional

\* Corresponding author. Kettegård Allé 30, 2650 Hvidovre, Denmark.

E-mail addresses: [bxh494@sund.ku.dk](mailto:bhx494@sund.ku.dk) (S.M. Bruhn), [stskou@health.sdu.dk](mailto:stskou@health.sdu.dk) (S.T. Skou), [lasse.kindler.harris@regionh.dk](mailto:lasse.kindler.harris@regionh.dk) (L.K. Harris), [thomas.quaade.bandholm@regionh.dk](mailto:thomas.quaade.bandholm@regionh.dk) (T. Bandholm), [amoeller@sund.ku.dk](mailto:amoeller@sund.ku.dk) (A. Møller), [lh.hs@dadlnet.dk](mailto:lh.hs@dadlnet.dk) (H.M. Schrøder), [anders.troelsen@regionh.dk](mailto:anders.troelsen@regionh.dk) (A. Troelsen), [lina.holm.ingelsrud@regionh.dk](mailto:lina.holm.ingelsrud@regionh.dk) (L.H. Ingelsrud).

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non-surgical treatment should be provided, while surgical treatment with knee arthroplasty may be relevant for some patients with end-stage radiographically verified OA [6]. Knee arthroplasty is considered to be an effective but costly treatment for end-stage knee OA [2,7]. However, even in patients with moderate-to-severe knee OA, eligible for knee arthroplasty, the non-surgical core treatment can be effective and can delay or potentially even prevent surgery [8,9]. Therefore, patients should undergo the full range of non-surgical first-line core treatments in primary care, regardless of OA severity, before consulting an orthopaedic surgeon [2,10]. Despite of the evidence and recommendations, studies report that compliance is inadequate and that these treatments are underutilised [11–15]. This evidence-to-practice gap in the treatment of OA might be reduced by optimising and increasing the utilisation of evidence-based non-surgical core treatments for knee OA before referral to surgery [2,7,16,17].

Unravelling current treatment pathways and clarifying which patients undergo certain treatment modalities before and after consulting an orthopaedic surgeon would be an important platform to optimise and adapt treatment pathways to increase utilisation of guideline-adherent treatment. Therefore, we aimed to describe 1) the proportion of patients undergoing the recommended combination of guideline-adherent core treatments, 2) which treatment pathways these patients undertake and 3) the characteristics of patients undertaking different treatment pathways before and until six months after primary referral to an orthopaedic surgeon.

## 2. Methods

This prospective cohort study was pre-registered with [ClinicalTrials.gov](https://www.clinicaltrials.gov) (NCT03746184). Reporting of the study follows The Strengthening of Reporting of Observational Studies in Epidemiology (STROBE) checklist for cohort studies [18]. In addition, this study reports on the first six months of follow-up of a longer-term prospective cohort study and pertains to the protocol objectives 1 and 2 [19]. The study was approved by the Danish regional ethical committee (Journal no.: H-17017295) and the Danish Data Protection Agency (Journal no.: AHH-2017-072).

### 2.1. Participants

Patients with primary referrals to an orthopaedic surgeon due to knee OA were consecutively invited from October 2018 to December 2020. Patients were included from Copenhagen University Hospital Hvidovre and Næstved Hospital in Denmark (representing both urban and more rural areas) from the outpatient clinics at the departments of orthopaedic surgery. Patients were included based on the general practitioners' diagnosis of knee OA, irrespective of which diagnostic criteria that were used. Patients referred with unspecified diagnoses such as "knee problems" or "knee pain" were invited if their age was  $\geq 40$  years, as this is the lowest age limit proposed by international recommendations for clinical OA criteria [3]. Exclusion criteria were previous knee replacement or osteotomy around the study knee and inability to read and write Danish.

### 2.2. Procedure

Through a secure e-mail, patients were invited to participate and answer an online questionnaire (Supplementary Table S1) approximately two weeks before the consultation with the orthopaedic surgeon. We sent up to two reminders. Patients who had not responded at the day of consultation were asked to fill out the questionnaire on a tablet or a paper-based questionnaire in the outpatient clinic. Questionnaire responses were collected prior to their consultation with the orthopaedic surgeon to avoid apprehension bias. To avoid introducing delays in the clinic due to study participation, patients were allowed to complete the questionnaire after their consultation if they had responded to questions about prior treatment for knee OA (Supplementary Table S1). Patients

who had their planned consultation moved to more than one month after responding to the questionnaire were asked to complete the questionnaire again before the new consultation. Six months after inclusion, we sent an online link to a follow-up questionnaire (Supplementary Table S1). To the approximately 15% of patients who did not have a secure e-mail, we sent paper-based questionnaires with a pre-paid return envelope. Reminders were sent electronically after one and two weeks and by post after five weeks, and a 2-month response window was accepted. Data were collected electronically through a secure Research Electronic Data Capture (REDCap) database [20].

### 2.3. OA treatment usage

Patients reported which treatments they had received at any point in time for knee OA from a predefined list of 19 treatments (Table 1). After six months, patients reported from the same list which treatments they had received since the consultation. The number of patients undergoing knee arthroplasty during the six-month follow-up period was extracted from the Danish Knee Arthroplasty Registry (DKR) with 97% coverage [21,22]. Patients who had a knee arthroplasty since inclusion were specifically asked for which other treatment modalities they had used up until their surgery and not to include any postoperative rehabilitation. Some of the 19 individual treatments with common features were grouped, which resulted in 13 treatment categories (Table 1): "Information and guidance on living with osteoarthritis" and "participation in GLA:D" (Good Life with osteoArthritis in Denmark, is an evidence-based program that includes education and supervised neuromuscular exercise delivered by certified physiotherapists [23]) were grouped into "patient education". "Exercise and gymnastics (strength training, fitness, or other type of exercise) under the supervision of a physiotherapist or similar", "water-based exercise in groups or under supervision", "exercise on your own (strength training, fitness or other type of exercise)" and "participation in GLA:D" were grouped into "exercise". "Insoles" and "assessment of the need for walking aid (walking stick, crutches, etc.);" were grouped into "walking aids and devices". Finally, "acupuncture", "massage", and "ultrasound, laser or other type of electrotherapy" were grouped into "passive treatment". Based on national and international clinical guidelines on the management of knee OA [1–4], we used a pragmatic approach to finding similarities between the guidelines to classify treatments as being 1) core treatment (patient education, exercise, dietary weight management, if needed [patients with body mass index (BMI)  $\geq 25$  or BMI  $\geq 30$ ]), 2) supplements to core treatment (pharmacological treatments, intra-articular injections, walking aids and devices, stretching and joint mobilisation), 3) end-stage treatment (knee arthroplasty), and 4) uncertain or not recommended treatment (arthroscopic surgery, passive treatment, alternative and complementary medicine, no treatment) (Table 1).

### 2.4. Patient characteristics, pain levels, functional limitations, and general health status

Patients reported demographics, BMI, comorbidities, physical activity, and duration of knee problems (Supplementary Table S1). Furthermore, we evaluated the average knee pain during the past week with a Visual Analogue Scale (VAS) (ranging from 0 (no pain) – 100 (worst imaginable pain) [100 mm scale]) [24], which is valid and reliable to measure pain in patients with knee OA and knee pain [25, 26]. The EQ-5D-3L measures the patients' self-reported health status on mobility, self-care, usual activities, pain/discomfort, and anxiety/depression and is expressed as an index score (ranging from  $-0.624$  (worst) to 1 (best)) [27]. The Oxford Knee Score (OKS) evaluates self-reported knee pain and function ranging from 0 (worst) to 48 (best). It has sufficient validity, reliability, and responsiveness to be used in this group of patients [28,29].

Routinely obtained standing antero-posterior, lateral and skyline view radiographs were evaluated by one of two assessors to evaluate 1) the

**Table 1**

Pre-defined list of 19 treatments in the questionnaires, grouped into 13 treatment categories and the overall classification of treatments. Patients reported which treatment(s) they had received for knee OA at inclusion and at six-month follow-up.

Classification of treatments	Treatment categories	Pre-defined list of treatments in the questionnaire
Guideline-adherent core treatment	1. Patient education	1. Information and guidance on living with osteoarthritis
	2. Exercise	2a. Participation in GLA:D <sup>a</sup> 2b. Participation in GLA:D <sup>a</sup>
Supplements to core treatment	3. Dietary weight management, if needed	3. Exercise and gymnastics (strength training, fitness, or other type of exercise) under the supervision of a physiotherapist or similar
	4. Pharmacological treatment	4. Water-based exercise in groups or under supervision
	5. Intra-articular injections	5. Exercise on your own (strength training, fitness or other type of exercise)
	6. Walking aids and devices	6. Diet or dietary guidance
End-stage treatment	7. Stretching	7. Pharmacological treatment (including painkillers)
	8. Joint mobilisation	8. Injection into the knee joint
Uncertain or not recommended treatment	9. Knee arthroplasty	9. Insoles
	10. Arthroscopic surgery	10. Assessment of the need for walking aid (walking stick, crutches, etc.)
	11. Passive treatment	11. Stretching
		12. Other manual therapy
		13. Total or unicompartmental knee arthroplasty <sup>b</sup>
		14. Arthroscopic surgery
		15. Acupuncture
		16. Massage
		17. Ultrasound, laser or other type of electrotherapy
	12. Alternative and complementary medicine	18. Alternative medicine (such as healing, Body SDS <sup>c</sup> , craniosacral therapy or similar)
	13. No treatment	19. No treatment

GLA:D, Good Life with osteoArthritis in Denmark.

SDS, Self-Development's System.

<sup>a</sup> GLA:D is an evidence-based program that includes education and supervised neuromuscular exercise delivered by certified physiotherapists [23].

<sup>b</sup> Information on whether the patients had knee arthroplasty was only collected at six-month follow-up.

<sup>c</sup> Body SDS is a concept that includes a wide range of therapies (e.g., massage, yoga, talking therapy) delivered by registered alternative therapists.

Kellgren–Lawrence (KL) classification of radiographic OA severity (ranging from 0 (none) to 4 (severe)) [30]; 2) the OA wear pattern, evaluated as lateral or medial, bicompartamental and/or severe patellofemoral for patients having a skyline view taken. The inter-rater reliabilities of the radiographic assessments were acceptable (supplement 2).

## 2.5. Data analyses

The sample size considerations were informed by the number of primary referrals during a 2-year inclusion period, and a planned prediction study [19]. For that study, with an expected event rate of 75% for the primary outcome (Patient Acceptable Symptom State [PASS]), including 2400 patients were required for models with 20 outcome events per variable and 30 predictor variables [19]. Data were analysed descriptively. The proportion of patients undergoing the recommended combination of guideline-adherent core treatments was calculated. As the definition of when dietary weight management would be needed varies among the clinical guidelines, we performed analyses using both BMI  $\geq 25$  and  $\geq 30$  kg/m<sup>2</sup> as criteria [1–4]. In addition, analyses were performed where the criterion of dietary weight management was excluded to explore the influence of that criterion. Furthermore, a sensitivity analysis was performed where unsupervised and water-based exercises were not considered as core exercise treatments. The number of treatment pathways to present depended on a data-driven approach that best described the distribution of data. Due to the SARS-CoV-2 pandemic, the healthcare facilities in Denmark were not accessible for several periods from March 14, 2020. Therefore, it seemed relevant to explore if there were differences in the treatments received in patients who responded to the six-month follow-up questionnaire before March 14, 2020, compared to patients who responded after. Whether continuous data should be presented as means or medians was determined by the normal distribution assessed with density and quantile–quantile plots. We used the statistical software program R for data management and analyses [31].

## 2.6. Patient involvement

To ensure study importance and relevancy from an end-user perspective, patients were involved in the planning and continuous

development of the project [32,33]. We established research priorities in OA based on a survey in almost 500 people with OA and “treatment” was one of the identified important research topics [33]. In addition, the aims and research questions of the study were discussed with two patients with knee OA. A total of 11 patients contributed with initial pre-testing of the questionnaire. Furthermore, six patients with knee OA were appointed as patient representatives and were invited to three meetings to help develop the questionnaires and share their views on the study progress.

## 3. Results

Out of the 5251 eligible patients, 3507 (66%) were included in the cohort. At six-month follow-up, 2574 (49%) had answered the questionnaire within the prescribed period, had complete data, and were included in the analyses (Fig. 1).

### 3.1. Characteristics of patients who were and were not included in the final analyses

The 2574 respondents who had complete data and were included in the analyses had a mean (SD) age of 66.1 (10.1) years, a mean (SD) BMI of 29.5 (5.7) kg/m<sup>2</sup> and 58% were female (Table 2). Compared to the information available for the 2677 eligible patients who did not participate in the study, there were no substantial age or gender differences (Supplementary Table S2). In comparison to participants with complete data, participants who did not respond to the six-month questionnaire had overall similar characteristics but were slightly younger (mean (SD) age was 62.8 (11.4) vs. 66.1 (10.1)), and a smaller proportion was retired (44% vs. 59%) (Supplementary Table S2).

### 3.2. Patients undergoing guideline-adherent core treatments

Of the three core treatments, exercise was the most utilised and patients who had reported education or dietary weight management had most often also reported exercise (Fig. 2). The proportion of patients receiving the recommended combination of guideline-adherent core treatments before the consultation with an orthopaedic surgeon (with

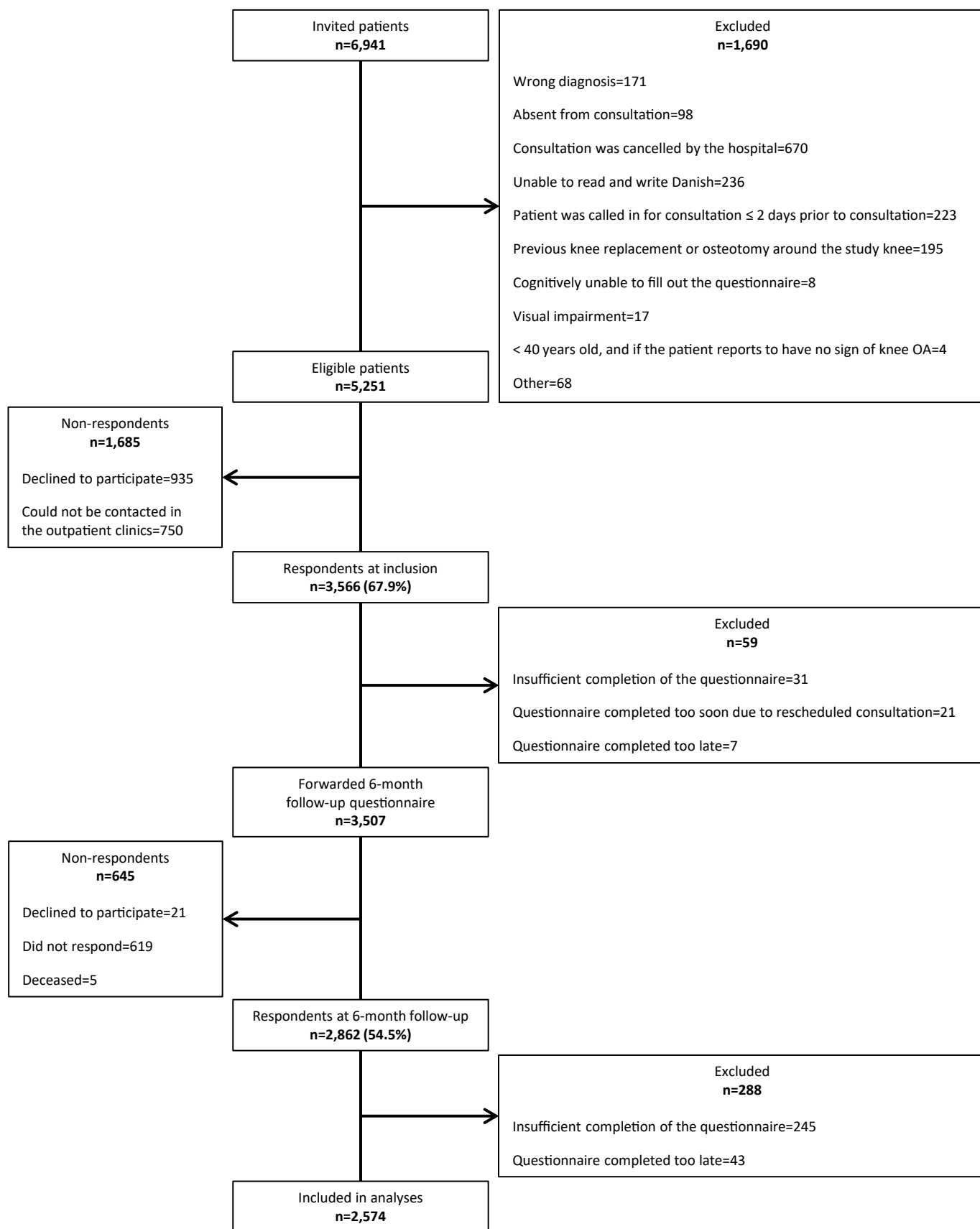


Fig. 1. Flowchart for patient inclusion and exclusion, non-respondents, reasons for exclusion and dropout and the number of respondents included in the analyses. Non-respondents were either patients who did not wish to participate in the study or were deceased in the follow-up time. In addition, non-respondents were patients who did not respond to our requests to answer the questionnaires and whom we could not contact in the outpatient clinics. Numbers in parentheses show the response rate for respondents at inclusion and at six-month follow-up, respectively.

Table 2

Patient characteristics for all included patients, patients receiving the recommended combination of guideline-adherent core treatments and patients who did not. Values are in percentages (%) with absolute numbers in parentheses unless other is stated.

	Included patients (n = 2574)	Patients receiving the recommended combination of guideline-adherent core treatments (n = 899)	Patients not receiving the recommended combination of guideline-adherent core treatments (n = 1675)
<b>Sex</b>			
Female	58% (1484)	65% (581)	54% (903)
<b>Age, mean (SD)</b>	66.1 (10.1)	67.4 (9.2)	65.4 (10.5)
<b>BMI, mean (SD)</b>	29.5 (5.7)	29.5 (5.7)	29.5 (5.7)
<b>Residential status</b>			
Alone	28% (729)	30% (273)	27% (456)
Cohabiting	69% (1766)	68% (607)	69% (1.159)
Missing	3% (79)	2% (19)	4% (60)
<b>Level of education</b>			
Elementary school	16% (407)	13% (120)	17% (287)
High school	2% (49)	3% (23)	2% (26)
Vocational education	31% (794)	27% (244)	33% (550)
Short-cycle higher education	13% (345)	14% (124)	13% (221)
Medium-cycle higher education	28% (722)	33% (293)	26% (429)
Long-cycle higher education or more	7% (172)	8% (76)	6% (96)
Missing	3% (85)	2% (19)	4% (66)
<b>Occupation</b>			
Retired, early retiree or on early retirement	59% (1518)	65% (587)	56% (931)
Sick leave part time or full time	6% (146)	5% (45)	6% (101)
Unemployed	3% (67)	3% (25)	3% (42)
On the labour market or student part time or full time	31% (808)	27% (245)	34% (563)
Missing	3% (82)	2% (18)	4% (64)
<b>Smoking</b>			
No, never	44% (1132)	46% (417)	43% (715)
No, but I used to	42% (1086)	44% (392)	41% (694)
Yes	11% (275)	8% (71)	12% (204)
Missing	3% (81)	2% (19)	4% (62)
<b>Comorbidities</b>			
Proportion of patients with comorbidities	76% (1949)	80% (716)	74% (1233)
<b>Self-reported physical activity per week</b>			
None	5% (116)	4% (35)	5% (81)
30 min	10% (265)	10% (86)	11% (179)
1 h	10% (262)	9% (85)	11% (177)
2 h	16% (399)	16% (145)	15% (254)
More than 2 h	57% (1460)	59% (533)	55% (927)
Missing	3% (72)	2% (15)	2% (57)
<b>VAS knee pain, mean (SD)</b>	63.7 (22.3)	65.1 (20.3)	62.9 (23.3)
<b>Duration of knee problems</b>			
0–6 months	15% (397)	10% (92)	18% (305)
7–12 months	13% (338)	12% (112)	13% (226)
1–2 years	17% (434)	16% (140)	18% (294)
3–5 years	20% (503)	22% (194)	18% (309)
6–10 years	14% (355)	15% (139)	13% (216)
>10 years	20% (517)	24% (215)	18% (302)
Missing	1% (30)	1% (7)	1% (23)
<b>EQ-5D-3L, median (IQR)</b>	0.723 (0.496–0.771)	0.708 (0.559–0.723)	0.723 (0.496–0.771)
<b>OKS, mean (SD)</b>	23.4 (8.0)	22.7 (7.5)	23.8 (8.3)
<b>Radiographical knee OA severity (KL grade)</b>	<b>a</b>	<b>c</b>	<b>e</b>
0	0 (0)	0 (0)	0 (0)
1	0 (3)	0 (2)	0 (1)
2	8 (260)	7 (75)	9 (185)
3	48 (1527)	47 (540)	49 (987)
4	41 (1293)	44 (506)	39 (787)
Missing	2 (67)	2 (28)	2 (45)
<b>Severe patellofemoral OA</b>	<b>b</b>	<b>d</b>	<b>f</b>
Yes	2 (50)	2 (23)	1 (27)
No	10 (315)	12 (134)	9 (181)
Not assessable	0 (15)	1 (8)	0 (7)
<b>Tibiofemoral OA wear pattern</b>	<b>a</b>	<b>c</b>	<b>e</b>
Medial	86 (2700)	85 (984)	86 (1716)
Lateral	11 (343)	11 (131)	11 (212)
Bicompartmental	1 (40)	1 (8)	2 (32)
Missing	2 (67)	2 (28)	2 (45)

BMI, body mass index ( $\text{kg}/\text{m}^2$ ); SD, standard deviation; VAS, Visual Analogue Scale (millimetres, 0–100); EQ-5D-3L, 3-level version of the European Quality of Life – 5 Dimensions; OKS, Oxford Knee Score; OA, osteoarthritis; KL grade, Kellgren and Lawrence classification system.

<sup>a</sup> Of the 2574 included patients, 576 had bilateral problems making the total number of examined knees 3150.

<sup>b</sup> Of the 3150 examined knees, skyline radiographs to assess severe patellofemoral OA were available for 380 knees.

<sup>c</sup> Of the 899 patients receiving the recommended combination of guideline-adherent core treatments, 246 had bilateral problems making the total number of examined knees 1145.

<sup>d</sup> Of the 1145 examined knees, skyline radiographs to assess severe patellofemoral OA were available for 165 knees.

<sup>e</sup> Of the 1675 patients not receiving the recommended combination of guideline-adherent core treatments, 330 had bilateral problems making the total number of examined knees 2005.

<sup>f</sup> Of the 2005 examined knees, skyline radiographs to assess severe patellofemoral OA were available for 215 knees.

BMI  $\geq 25$  as the criterion for whether dietary weight management was needed) was 6% (146 patients). When increasing the criterion for whether dietary weight management was needed to BMI  $\geq 30$ , the proportion was 14% (362 patients). At six months after the consultation, the proportion increased to 9% (242 patients) using BMI  $\geq 25$  as the criterion and 23% (580 patients) using BMI  $\geq 30$ . If excluding the criterion about dietary weight management, 21% (537 patients) reported to have received both patient education and exercise before the consultation. This proportion increased to 35% (899 patients) six months after the consultation. When additionally restricting the exercise criterion to supervised land-based exercise, the proportion was 20% (507 patients) before, increasing to 33% (861 patients) after six months.

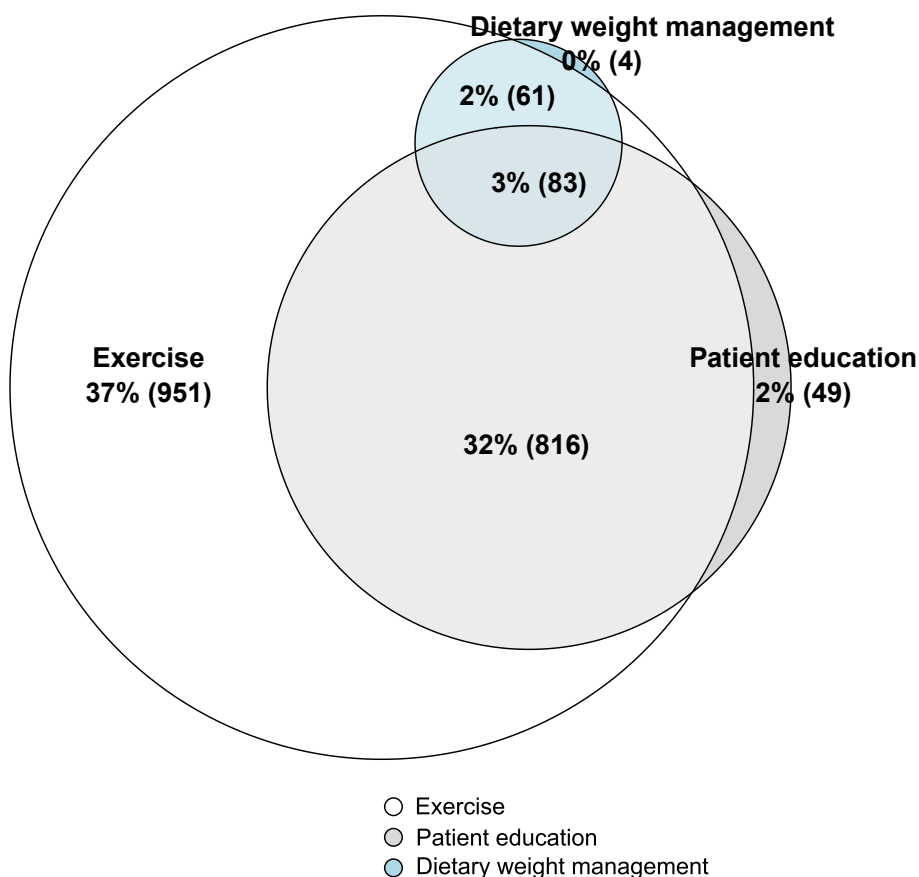
Exercise, pharmacological treatments, and patient education were the single most utilised treatments both before and in the following six months after the consultation. The proportion of patients reporting to have received any type of exercise was 54% (1380) before the consultation, increasing to 74% (1911) until six months after. Supervised land-based exercise was reported by 41% (1054 patients) before the consultation, increasing to 62% (1601) until six months after. Pharmacological treatments were received by 44% (1144) of the patients before the consultation, increasing to 52% (1329) until six months after, and patient education by 23% (580) before the consultation, increasing to 37% (948) until six months after (Table 3). The proportion of patients who had not received any treatment for knee OA decreased from 21% (548) before the consultation to 10% (245) six months after.

In general, patients receiving the recommended combination of core treatments had largely similar characteristics to those who did not (Table 2). However, patients receiving core treatments tended to be females (65% vs. 54%), with a higher level of education, a longer duration of knee problems, more often retired, and have comorbidities (Table 2).

The proportion of patients who received the recommended combination of guideline-adherent core treatments were similar for patients completing the six-month follow-up questionnaire before and after the first national lockdown due to the SARS-CoV-2 pandemic (Supplementary Table S3). The proportion of patients who had knee arthroplasty was larger for patients responding before the lockdown (Supplementary Table S4).

### 3.3. Treatment prior to knee arthroplasty

During the six months after consulting an orthopaedic surgeon, 31% (797 out of 2574) patients had a knee arthroplasty. Out of these, 9% (75) had received the recommended combination of core treatments before surgery, with BMI  $\geq 25$  as the criterion for when dietary weight management was needed. With BMI  $\geq 30$  as the criterion, the proportion was 24% (190 patients). If excluding the criterion about dietary weight management, 37% (297) had received the core treatments (patient education and exercise) before surgery. There were 7% (59) of the patients who did not receive any treatment prior to surgery. For those undergoing knee arthroplasty, any type of exercise, pharmacological treatments, and patient education were still the most utilised treatments until surgery, with the



**Fig. 2.** Number of patients receiving the guideline-adherent core treatments and combinations until six months after the consultation. Combinations of core treatments are illustrated as one or more circles overlapping another. Percentages represent the proportions out of all 2574 included patients. The number of patients reporting to have received dietary weight management is displayed for all, disregarding their BMI. It should be noticed that dietary weight management was only relevant for 2110 patients with BMI  $\geq 25$  and for 1084 patients with BMI  $\geq 30$  (Table 3).

**Table 3**

Percentage and number of patients reporting to have received each separate treatment before consulting an orthopaedic surgeon, between consultation and six-month follow-up and until six months after the consultation for patients not undergoing knee arthroplasty and until surgery for patients undergoing knee arthroplasty.

Classification of treatments	Treatment categories	Patients reporting to have received each separate treatment (n = 2574)		
		Before consulting an orthopaedic surgeon, % (n)	Between consultation and six-month follow-up, % (n)	In the entire disease course until six months after consultation, % (n)
Guideline-adherent core treatment	1. Patient education	23 (580)	23 (604)	37 (948)
	2. Exercise	54 (1380)	53 (1361)	74 (1911)
	3a. Dietary weight management, if needed (BMI $\geq$ 25)	5 (97) <sup>a</sup>	3 (57) <sup>a</sup>	7 (145) <sup>a</sup>
Supplements to core treatment	3b. Dietary weight management, if needed (BMI $\geq$ 30)	7 (72) <sup>b</sup>	4 (48) <sup>b</sup>	10 (111) <sup>b</sup>
	4. Pharmacological treatment	44 (1144)	23 (581)	52 (1329)
	5. Intra-articular injections	13 (331)	7 (188)	16 (451)
	6. Walking aids and devices	11 (284)	7 (184)	15 (397)
	7. Stretching	6 (146)	4 (100)	9 (230)
	8. Joint mobilisation	2 (61)	2 (40)	4 (94)
	9. Knee arthroplasty	0 (0)	31 (797)	31 (797)
End-stage treatment	10. Arthroscopic surgery	17 (427)	5 (119)	20 (508)
Uncertain or not recommended treatment	11. Passive treatment	18 (456)	10 (244)	22 (574)
	12. Alternative and complementary medicine	4 (89)	2 (48)	5 (116)
	13. No treatment	21 (548)	33 (856)	10 (245)

BMI, body mass index (kg/m<sup>2</sup>).

<sup>a</sup> Out of 2110 patients with BMI  $\geq$  25.

<sup>b</sup> Out of 1084 patients with BMI  $\geq$  30.

proportion of patients reporting to have received these treatments being 77% (611), 61% (484), and 40% (316), respectively (Table 4).

Among the 297 patients receiving the recommended core treatment combination before surgery, the proportion of females was larger (63% women) compared to the 500 patients who did not (53% women) and the 59 patients who did not receive any treatment (36% women) (Supplementary Table S5). Other patient characteristics were largely comparable, but those not receiving any treatment tended to, have lower education levels, slightly better OKS, shorter duration of knee problems and fewer were retired (Supplementary Table S5).

### 3.4. Usage of combinations of different treatments

From all possible combinations of the 13 treatment categories, the five most common treatment pathways for knee OA were: 1) No treatment initially followed by no treatment after consultation: 7% (186) of the patients, 2) no treatment initially followed by exercise after consultation: 3% (88) of the patients, 3) pharmacological treatment initially,

followed by no treatment after consultation: 3% (65) of the patients, 4) exercise initially followed by no treatment after consultation: 2% (60) of the patients, 5) no treatment initially followed by no other treatment but knee arthroplasty after consultation: 2% (59) of the patients. The total number of unique pathways was 1143, and 871 pathways were pursued by only one patient. Treatments that were not recommended or recommended against were included in 62% (707) of the pathways. Exercise was included in most pathways (87% (998)), 7% (78) of the 1143 treatment pathways comprised the recommended combination of core treatments, and 10% (111) of the treatment pathways did not contain any core treatment (Fig. 3).

## 4. Discussion

We prospectively followed a cohort of 2574 patients with knee OA in six months from their first consultation with an orthopaedic surgeon. We found that only 35% of these patients had received the recommended combination of guideline-adherent core treatments exercise and patient

**Table 4**

Percentage and number of patients reporting to have received each separate treatment until surgery for patients undergoing knee arthroplasty and until six months after the consultation for patients not undergoing knee arthroplasty.

Classification of treatments	Treatment categories	Patients reporting to have received each separate treatment (n = 2574)	
		Patients undergoing knee arthroplasty (n = 797), % (n)	Patients not undergoing knee arthroplasty (n = 1777), % (n)
Guideline-adherent core treatment	1. Patient education	40 (316)	36 (632)
	2. Exercise	77 (611)	73 (1300)
	3a. Dietary weight management, if needed (BMI $\geq$ 25)	7 (47) <sup>a</sup>	7 (98) <sup>b</sup>
Supplements to core treatment	3b. Dietary weight management, if needed (BMI $\geq$ 30)	10 (34) <sup>c</sup>	10 (77) <sup>d</sup>
	4. Pharmacological treatment	61 (484)	48 (845)
	5. Intra-articular injections	17 (132)	18 (319)
	6. Walking aids and devices	18 (144)	14 (253)
	7. Stretching	10 (78)	9 (152)
	8. Joint mobilisation	3 (24)	4 (70)
	9. Knee arthroplasty	100 (797)	0 (0)
End-stage treatment	10. Arthroscopic surgery	21 (170)	19 (338)
Uncertain or not recommended treatment	11. Passive treatment	20 (162)	23 (412)
	12. Alternative and complementary medicine	4 (30)	5 (86)
	13. No treatment	7 (59)	10 (186)

BMI, body mass index (kg/m<sup>2</sup>).

<sup>a</sup> Out of 673 patients with BMI  $\geq$  25.

<sup>b</sup> Out of 1437 patients with BMI  $\geq$  25.

<sup>c</sup> Out of 349 patients with BMI  $\geq$  30.

<sup>d</sup> Out of 735 patients with BMI  $\geq$  30.

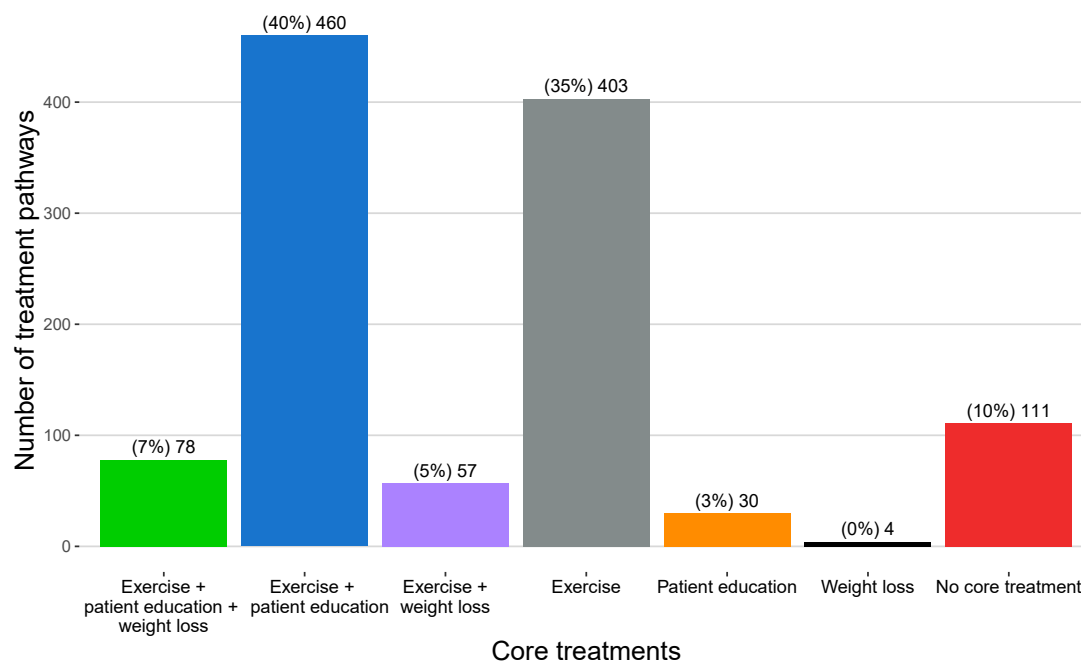


Fig. 3. The number of treatment pathways comprising one or more core treatments.

education, while that proportion decreased to 23% when also considering if dietary guidance was received if needed. Patients who had received core treatments had largely similar characteristics to those who did not undertake core treatments but tended to be females, with a longer duration of knee problems, a higher education level, more often retired, and have comorbidities. Additionally, describing the most common combinations of individual treatments was challenged by the finding that the 2574 included patients comprised 1143 unique treatment pathways, suggesting no consistent and systematic use of specific treatment pathways. Only 7% (78) of the pathways included the recommended combination of guideline-adherent core treatments and 62% (707) included treatments that were not recommended or recommended against.

The inferior use of guideline-adherent core treatments for knee OA has been repeatedly shown in studies from several countries. Our results confirm the findings from two systematic reviews showing that, overall, non-drug and non-operative OA treatment, including education and self-management or referral or recommendation to exercise, was recommended to fewer than 40% of the patients [12,15]. The proportion of patients reporting to have used any type of exercise was higher in our study, but we found a similar proportion reporting land-based supervised exercise before consultation (41%), and that proportion increased until the six-month follow-up. The proportion of patients undertaking the recommended combination of core treatments was not impacted by the exercise criterion, indicating that most patients receiving supervised land-based exercise also received patient education and dietary weight management, if needed. Despite differences in study design and healthcare settings, all previous studies conclude that recommended treatments for knee OA are underutilised [11,12,14,15,34,35]. Another finding from our study was that only 23% of the patients underwent the recommended combination of core treatments until six months after consulting the orthopaedic surgeon. In Canada, guideline-adherence was found in 19% of patients being recommended non-surgical treatment by an orthopaedic surgeon [36]. Additionally, we found that in those proceeding to knee arthroplasty, the proportion was 24%, which was considerably lower than in Canada, where 60% were found to have used recommended core treatments before surgery [34]. Differences in core treatment definitions can possibly explain some of the discrepancy since the proportion reporting to have undergone exercise was similar across studies, but in

the Canadian study, almost 70% had reported to have tried dietary weight management. Our dietary weight management criterion was stricter as we had asked patients whether they had received a diet or dietary weight management with a dietician. As the costs for dietary treatment and most often exercise are not covered by the national health security system in Denmark, there may have been a financial barrier for undertaking dietary weight management and exercise [37,38]. Altogether, patients with knee OA undertake a large variety of treatments, often not in accordance with clinical guidelines. Since knee OA develops gradually and symptoms may fluctuate over many years, patients might seek different treatments themselves without involving the public healthcare system. However, our study included patients referred to evaluate the need for surgery, meaning that many patients were offered other treatments than the guideline-adherent core treatments, also as first-line treatments [39].

Patients undertaking core treatments had largely similar characteristics to those who did not. Our findings were similar to a smaller cohort of 195 patients from the Netherlands, where no differences in patient characteristics were found for those complying with guidelines and not [35]. However, a Canadian study reported that being female and having a higher level of education was associated with using recommended treatments, which were similar to the tendencies described in our study, but in contrast to our findings, patients undertaking the recommended treatments were younger [34]. The mean age differences between core treatment users and non-users were only two and four years in our and the Canadian study, respectively, suggesting that the impact of age is negligible. A potential reason why men use less core treatments is that they are more likely to undergo knee arthroplasty earlier in their course of disease [40].

There may be several barriers influencing which treatments the patients undergo. A barrier for healthcare providers to refer to physiotherapy could be the belief that patients will be offered non-evidence treatments and the misbelief that the effect of therapeutic exercise is questionable [41–44]. Healthcare providers' mistrust in the management of dietary guidance was also pointed at as a possible barrier for receiving recommended treatment for knee OA [41,44]. Additional barriers may be the healthcare provider's insufficient knowledge of available recommended treatment or if knee OA is simply perceived as a normal



procedure of aging [41,43,44]. Patients have also reported several potential barriers for use of recommended treatment, such as having too much pain or too severe radiographical OA [42]. If individuals in the patients' environment have had positive experiences with surgery, or if the general practitioner has a preference for surgical treatment, it could also be barriers for receiving recommended treatment [42]. Understanding what influences which treatments the patients undergo for knee OA is complex and further research is needed in this area.

#### 4.1. Strengths and limitations

Strengths of this study include the large number of participants and the prospective design with a follow-up questionnaire to obtain information on treatments received both before and after the consultation, which also makes it possible to explore changes in treatment pathways after seeing the surgeon. Patients were recruited from two high-volume orthopaedic departments in different parts of Denmark, which increases the generalisability of our findings. When consecutively inviting all patients referred by the general practitioner to an orthopaedic surgeon due to diagnosed knee OA or symptoms associated with knee OA it reflects the actual clinical practice, hence making the study results more representative and clinically relevant. Despite the effort to consecutively include the eligible patients, we were only able to include half of the eligible patients in the final analyses, which might have led to a risk of selection bias [45,46]. Patients who were not included in the final analyses were, on average, younger and a smaller proportion were retired. Especially patients who were retired tended to receive the core treatments, meaning that the proportion of patients who received the core treatments could potentially have been even smaller if the response rate had been higher. In addition, a relatively large proportion were excluded because they were unable to read and write Danish, limiting the generalisability of our results. Furthermore, recall bias may potentially impact our findings since data were mainly self-reported [12,47]. Recall bias may especially have impacted on reported treatment until the first consultation, since we asked for any treatment used during the whole knee OA disease course [47]. However, no registries in Denmark contain information about all relevant treatment usage for knee OA. The results of this study may be more relevant for patients with a more severe degree of knee OA because the study cohort is based on patients referred to an orthopaedic surgeon for assessment for knee replacement surgery, and more than 90% had KL grade  $\geq 3$ . However, our cohort was also comprised of patients with mild radiographic OA (KL grade 1 or 2) in 8%, and 22% had an OKS  $\geq 30$ , corresponding to the threshold indicating satisfactory symptom-levels after surgery, suggesting that the study results are representative for the target population with both a mild/moderate and more severe degree of knee OA [48].

#### 5. Perspectives

Improving guideline adherence is important to optimise the treatment of knee OA [49]. Our findings provide a foundation for advancing guideline adherence by describing current treatment usage and clarifying treatment pathways. Information provided by this study about patient characteristics and other possible predictive variables can be used in future studies investigating determinants of outcomes of available treatments. Such initiatives can be useful to target treatment to the individual patient and aid with shared decision making.

#### 6. Conclusion

Only one in four patients with knee OA underwent treatment pathways in accordance with clinical guidelines until six months after consulting an orthopaedic surgeon or until surgery for those undergoing knee arthroplasty. All types of exercise were reported by almost three in four patients, while supervised land-based exercise was reported by less than two in three. Patient education was reported by slightly more than

one in three patients, and dietary weight management was only reported by one in ten of those for whom it was relevant. Our results highlight that the recommended core treatments are severely underutilised before surgery. In addition, the proportion of patients receiving no treatments or treatment that were not recommended or recommended against, and the large number of different treatment pathways, suggests a need for a more structured effort to increase the use of guideline-adherent core treatments.

#### Author contributions

Study conception and design: SMB, STS, TB, AM, HMS, AT and LHI. Interpretation of data, critical revision for important intellectual content and final approval of the article: SMB, STS, LKH, TB, AM, HMS, AT and LHI.

Acquisition of data: SMB, LKH and LHI.

Analysis of data and drafting of the manuscript: SMB and LHI.

Simon Majormoen Bruhn ([simon.majormoen.bruhn@regionh.dk](mailto:simon.majormoen.bruhn@regionh.dk)), Anders Troelsen ([anders.troelsen@regionh.dk](mailto:anders.troelsen@regionh.dk)) and Lina Holm Ingelsrud ([lina.holm.ingelsrud@regionh.dk](mailto:lina.holm.ingelsrud@regionh.dk)) take responsibility for the integrity of the work as a whole (from inception to finished article).

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#### Declaration of competing interest

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#### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ocarto.2023.100411>.

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