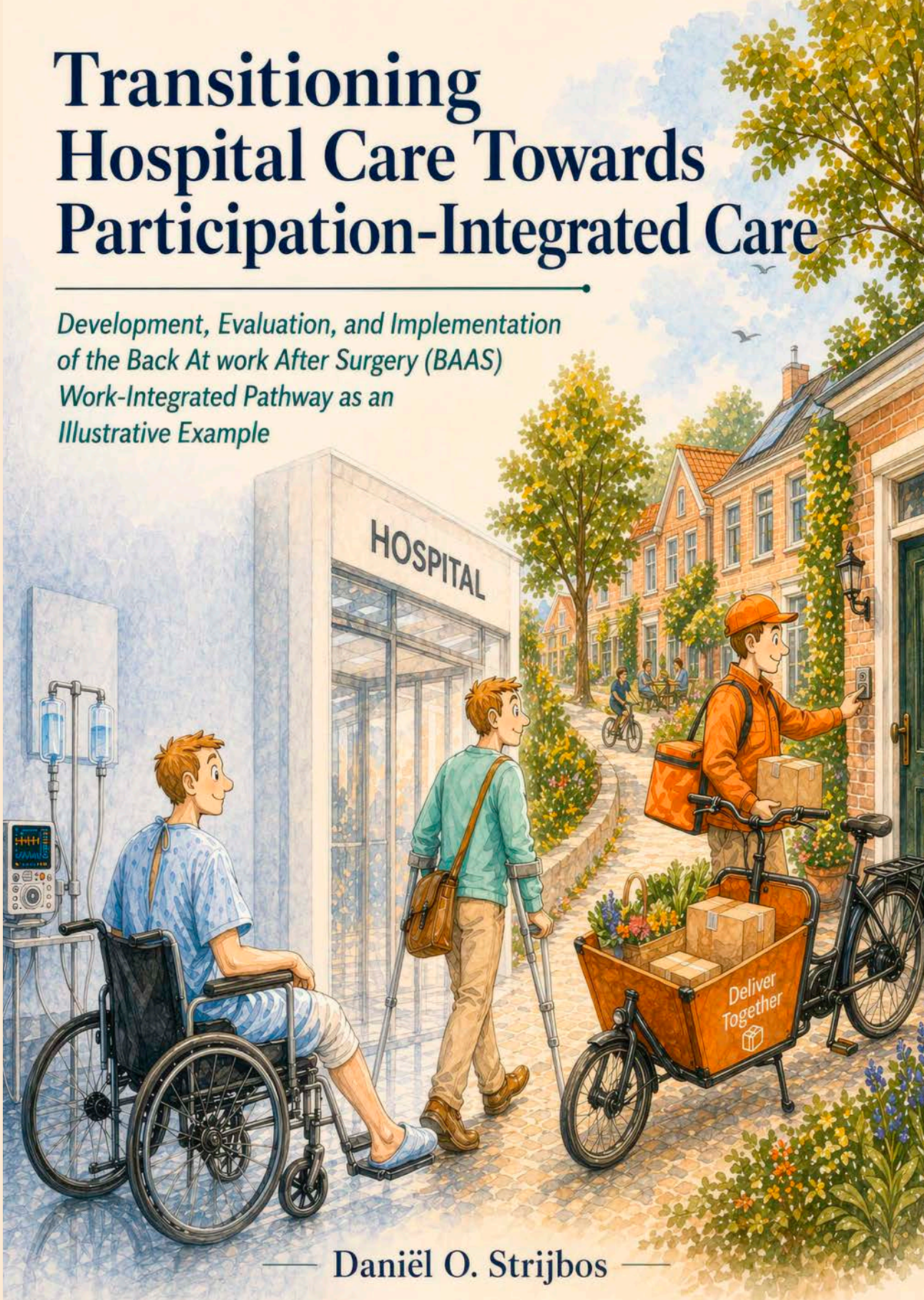


Transitioning Hospital Care Towards Participation-Integrated Care

*Development, Evaluation, and Implementation
of the Back At work After Surgery (BAAS)
Work-Integrated Pathway as an
Illustrative Example*



— Daniël O. Strijbos —

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Daniël Otto Strijbos

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Development, Evaluation, and Implementation of the Back At work After Surgery (BAAS) Work-Integrated Pathway as an Illustrative Example

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CHAPTER

1

General introduction

General introduction

Hospitals continue to play a central role in modern healthcare systems, with approximately 35 million hospital admissions annually in the United States and about 3 million in the Netherlands.^{1,2} Over recent decades, hospital care has undergone significant transformation, with healthcare systems across Europe reporting increased efficiency and effectiveness in clinical care delivery in terms of reduced inpatient capacity, increased day surgery rates, improved bed turnover, and shorter lengths of stay.³ In the Netherlands, for example, four-year survival after a cancer diagnosis has increased from 51% around thirty years ago to 72% today, likely reflecting advances in diagnostics, surgery, and systemic treatment.⁴ The increase in life expectancy is another example of improved clinical care. For instance, in the United States, life expectancy at birth increased from 47.3 years in 1900 to 78.7 years in 2010.⁵

Despite the positive trends in these hospital medical outcomes, a hospital admission constitutes more than a clinical intervention; it represents a significant life event that can disrupt patients' functional abilities and participation in daily life long after discharge. An integrative review confirmed that hospitalization negatively affects patients' ability to cope and adjust, exacerbating emotional responses and psychological distress.⁶ Among older adults, hospitalization is a well-established risk factor for hospital-associated disability, defined as a new loss of independence in activities of daily living following an acute stay. A recent meta-analysis reported a pooled prevalence of 30% hospital-associated disability, with affected individuals facing increased risks of long-term functional decline, nursing home admission, and even mortality.⁷ In other words, while hospitals increasingly save lives and extend survival, they can still leave patients vulnerable in ways that traditional medical outcomes overlook.

Despite the evident importance of hospital admissions as significant life events, there remains considerable ambiguity regarding what constitutes "recovery" after hospitalization. The meaning of recovery varies significantly among different stakeholders, including patients, healthcare professionals, and policymakers. Understanding this discrepancy requires examining how these patients, healthcare professionals and policy makers, conceptualize recovery after a hospital stay.

Patients often conceptualize their recovery in personal terms, emphasizing the return to meaningful daily activities, independence, and active engagement in their communities.^{8,9} Studies among patients recovering from orthopedic

procedures, such as knee replacements or hip fractures, underline that patients prioritize outcomes like regaining autonomy, outdoor mobility, and participation in valued social and occupational roles as critical indicators of successful recovery.¹⁰⁻¹² Moreover, psychological well-being, confidence, and the ability to manage residual symptoms are frequently described as equally essential components of recovery by patients.^{8,13} Importantly, for working-age individuals, returning to work is not only a marker of functional recovery but also of identity and social participation, yet it is often overlooked in routine care.^{12,13} Despite these priorities, recent research suggests that work-related functioning does not always receive sufficient attention during clinical consultations. Patients report that they would welcome more discussion of how illness and treatment affect their ability to work and expect physicians to address this proactively.¹⁴

From the healthcare professional's perspective, recovery after surgery is more commonly viewed in terms of biomedical and functional milestones, such as pain reduction, joint mobility, and the absence of complications within the ICF domains of body functions and structures.^{11,15,16} These priorities are also reflected in professional quality registries and clinical audit systems, which predominantly capture clinically oriented outcomes such as complication rates, range of motion, or implant survival. This persistent divergence between medical and patient-defined recovery highlights the need to broaden the scope of healthcare evaluation and better align it with individual goals and patient-desired participation-based outcomes.

From the perspective of Dutch policymakers, recovery is often assessed indirectly through system-level performance dashboards that emphasize organizational indicators, such as waiting times, length of stay, readmissions, and mortality.¹⁷ Although the Ministry of Health, Welfare and Sports (VWS) also covers Sport as a participation domain, routine performance sets still seldom include participation-based outcomes such as return to work.¹⁷ At the same time, the Dutch "passende zorg" agenda explicitly shifts attention to value, shared decision-making, and what people can do.¹⁸ The VWS-monitor's own advisory note flagged the absence of an indicator capturing how quickly people resume work after a care episode, yet, in the latest agenda work is still not included as an indicator.^{19,20} The Ministry of Social Affairs and Employment (SZW) 2023–2027 Knowledge Agenda calls for interdepartmental collaboration between work and health but makes few concrete commitments to link healthcare metrics to work-oriented outcomes like return to work.²¹ In contrast, the Social and Economic Council (SER) urges embedding work into diagnosis, treatment, nursing and reintegration, proposes exploring a DBC for work-related specialist care, and presses to improve alignment

between occupational and regular care, pushing participation explicitly into the healthcare remit.²² Business and policy voices echo this direction: in a column in an economic policy journal, the secretary of economy and health of the Dutch Confederation of Netherlands Industry and Employers and Small and Medium-sized Enterprises (VNO-NCW and MKB Nederland) argues for “going all-in on work” to promote a healthier Dutch population.²³ In sum, despite repeated endorsements, tangible system-level changes to embed participation, especially return to work, in healthcare have not been put into practice.

In summary, these examples show differences among patients’ healthcare professionals’ and policy makers’ perspectives. Regarding the concept of recovery after hospitalization, the scientific literature supports the inclusion of patient-centered and participation-oriented outcomes in its evaluation. Conceptual papers similarly frame recovery as a complex, multidimensional, and energy-demanding process—encompassing the restoration of physical, psychological, social, and habitual functioning, and advocate moving beyond narrowly defined medical benchmarks toward holistic, patient-centered evaluations focused on meaningful daily activities, societal roles, and emotional well-being.^{24,25} Furthermore, qualitative research underscores that patients consistently emphasize regaining autonomy, restoring social connections, and re-engaging in meaningful life roles as central to their experience of recovery.²⁶

In line with this evolving understanding of recovery, both policy and research systems are increasingly recognizing the need to embed patient voices structurally in the evaluation of healthcare. Internationally, patient and public involvement (PPI) is transforming how research priorities are set, how funding is awarded, how guidelines are developed, and how outcome measures are selected.^{27,28} In the Netherlands, this shift is visible in ZonMw’s funding criteria, which increasingly require meaningful involvement of patients across all phases of research, and in the development of clinical quality standards and national health registries that embed patient representatives.²⁸ At the same time, several Dutch clinical guidelines—especially older or more biomedically oriented ones—still fail to incorporate participation-based outcomes such as work resumption or social role functioning, despite long-standing national and international recommendations to do so.^{29–31} This underscores a structural gap between what patients define as meaningful recovery and what healthcare systems currently measure and value. Truly patient-centered care therefore requires not just understanding individual recovery goals, but structurally embedding outcomes like autonomy, return to work, and participation in the very systems that define, monitor, and reward healthcare performance.

Defining participation as a key health outcome

Participation is increasingly recognized as a vital dimension of health and well-being. According to the World Health Organization's International Classification of Functioning, Disability and Health (ICF), participation refers to "involvement in a life situation" and encompasses engagement in various societal roles, such as work, family life, education, sports, leisure activities, and community involvement.¹⁶ This definition highlights the shift from purely biomedical outcomes towards a holistic understanding of health that integrates physical, psychological, and social aspects.

Meaningful participation can take many forms and differs greatly among individuals. For one person, successful participation after hospitalization might mean returning to competitive sports; for another, it could involve everyday activities such as caring for grandchildren, practicing religion, or shopping for groceries independently. This variability, and the inherently personal value individuals attach to different activities, makes participation challenging to measure systematically. Recent developments of instruments such as the PROMIS "Ability to Participate in Social Roles and Activities" item bank attempt to bridge these gaps by adding validated items that address under-represented domains like volunteering, digital participation, and assisting others.³²

However, among the various dimensions of participation, return to work stands out as particularly relevant and measurable. Return to work safeguards financial autonomy, fosters social connectedness, and reinforces personal identity: qualitative studies show that patients regard employment as a source of financial security, meaningful social contacts, and "feeling needed in society".^{13,33} Sustained work participation is further linked to better physical and mental health and to broader economic benefits, whereas prolonged work disability drains social insurance resources and undermines psychosocial well-being.³⁴ Recognizing its importance, an international multistakeholder Delphi exercise recently identified employment status, proportion returning to work, and time to return to work as the three core outcomes that should always be reported in work-participation research.³⁵ Encouragingly, a companion meta-analysis found that patient-reported return to work differs on average by only ~1.8 days from registry data and shows high sensitivity (0.83) and specificity (0.92), indicating that simple, standardized self-report questions can be sufficiently accurate.³⁶ Nevertheless, multiple Cochrane reviews highlight that inconsistent outcome definitions continue to hamper evidence synthesis in occupational-health trials, underscoring the need for the emerging core outcome set to be widely adopted.³⁷⁻³⁹

Despite its demonstrated importance, return to work is seldom addressed in standard hospital pathways; consultations remain focused on short-term medical outcomes rather than on patients' ability to resume employment.¹⁴ This practice gap is increasingly at odds with modern policy frameworks. The Quadruple Aim, later expanded to the Quintuple Aim, adds workforce well-being and health equity to the original goals of better care, population health, and lower cost—goals that clearly encompass work participation as an outcome that matters to both patients and clinicians.^{40,41} Simultaneously, Value-Based Healthcare defines value as health outcomes that matter to patients relative to costs, urging systems to measure and reward outcomes such as sustainable return to work rather than process compliance alone.^{42,43} Embedding return to work metrics—employment status, time to return to work, and sustainable return to work—into routine evaluation would therefore align peri-operative care with patient priorities, clinician well-being, and wider societal value, providing a consistent basis for policy, reimbursement, and quality improvement.

Orthopedic surgery as an illustrative example

Orthopedic surgery provides an illustrative example of why return to work and work-integrated care deserve specific attention within healthcare. Orthopedic procedures are performed in high volumes and commonly affect patients within the working-age population. Annual data from Western countries reflect this high volume; for instance, approximately 95,000 hip replacements and 100,000 knee replacements were conducted in 2018 in the United Kingdom.⁴⁴ In the United States, 370,000 and 680,000 primary hip and knee replacements were performed in 2014.⁴⁵ Lastly, in the Netherlands, 43,000 primary hip replacements and 36,000 primary knee replacements were performed in 2024.⁴⁶ The numbers of orthopedic surgeries are not only high but are also predicted to be strongly increasing in the coming years. For example, knee and hip replacement surgeries are predicted to increase by 673% and 174% from 2005 to 2030 in the US, 38 and 37% between 2018 and 2060 in the UK and 297% and 149% from 2005-2030 in the Netherlands, respectively.^{44,47,48}

Especially in patients who have knee arthroplasty, the largest increase is not among the classic knee arthroplasty population of patients aged 70 years and older, but among patients of working age.⁴⁹⁻⁵² For instance, Germany, one of the leading countries in the prevalence of knee arthroplasty, is projected to see the highest increase in patients of working age.^{49,50} In several countries, the current proportion of knee arthroplasty patients under 65 years is already substantial at 30–40%. By 2030,

the USA is expected to be the first country where the majority of patients having knee arthroplasty will be younger than 65 years, followed by the UK in 2035.^{47,52}

Returning to work after knee arthroplasty can be a challenge. A systematic review pooling 44 cohorts calculated a mean return-to-work rate of just 65%, implying that roughly 35% of working-age patients remain absent from work one year after total knee arthroplasty.⁵³

Qualitative and quantitative studies consistently point to modifiable contributors, including physically demanding jobs, extended pre-operative sick leave and misaligned recovery expectations, none of which are addressed by routine implant-centered follow-up.^{12,13,54} Together these figures underscore that conventional success metrics, pain relief, range of motion and implant survival, do not capture outcomes that matter most to today's younger, economically active population of patients having knee arthroplasty. Embedding explicit, evidence-based vocational targets and multidisciplinary work-integrated rehabilitation into peri-operative pathways is therefore imperative to close this persistent participation gap after knee arthroplasty.

Introducing the hospital-led Back At work After Surgery work-integrated pathway

The growing problem of return to work after knee arthroplasty stimulated the conception of Back At work After Surgery (BAAS). This hospital-led, work-integrated pathway was designed to fill the evident gap between routinely excellent implant-centered outcomes (pain relief, range of motion, implant survival) and the outcomes that matter most to working patients: regaining productive participation in paid work.⁵⁵

The development of the BAAS work-integrated clinical pathway has its roots in 2020, when insurance company a.s.r. asked hospital Nij Smellinghe whether patients could be trained before surgery to enhance the return to work rate and speed after surgery. Nij Smellinghe is one of the leading hospitals in the Netherlands in implementing prehabilitation, a coordinated preoperative program combining exercise training, nutritional optimization, risk-behavior modification (e.g., smoking/alcohol cessation), and psychological support to build physiological reserve and improve postoperative outcomes.^{56,57} Because prehabilitation appears most effective among elderly frail patients, and working-age patients most often do not belong to this group, we hypothesized that it

would be better to guide patients throughout the perioperative period rather than only train before surgery.^{58,59}

During its development, the BAAS team formulated two core design principles:

1. Timely integration of medical and occupational care – By merging peri-operative orthopedic rehabilitation with proactive occupational health management, BAAS aims to prevent the fragmentation of advice that patients commonly experience when they shuttle between hospital, physiotherapy practice and workplace health services.
2. Active patient participation and goal-setting – Drawing on Goal Attainment Scaling and continuous activity monitoring, the pathway positions patients as partners who co-define meaningful, work-oriented milestones and track their own progress.

Both principles reflect contemporary value-based and person-centered healthcare frameworks, and operationalize them in a concrete, workflow-ready manner.

The BAAS pathway spans the entire surgical episode, from the decision to operate until full return to work:

Pre-operative phase

The orthopedic surgeon discusses return to work expectations and known prognostic factors with the patient and recommends early contact with the occupational physician; the patient is then referred to a hospital-based physical therapist for baseline questionnaires and functional testing, and is issued an accelerometer to monitor physical activity with real-time feedback options. The role of the orthopedic surgeon at this stage, explicitly addressing return to work and setting expectations, is supported in the clinical pathway description.⁶⁰ A work-related goal is formulated using Goal Attainment Scaling to anchor rehabilitation in job-specific demands.⁶¹ An occupational assessor conducts a workplace assessment and compiles a report of facilitators and barriers for return to work, which is shared with the occupational physician and both the hospital-based and primary-care physical therapists.

Early post-operative phase (0–6 weeks)

Ward-based care follows enhanced-recovery principles as part of care-as-usual. Around week four to five after surgery, a structured online interdisciplinary consultation, including the patient, the primary-care physical therapist, the

hospital-based physical therapist, the occupational assessor and the occupational physician, reviews recovery and aligns rehabilitation goals with a tailored return to work plan.

Later post-operative phase (6 weeks–12 months)

Recovery is again monitored at approximately six weeks and then at regular intervals of three months, using the same patient-reported outcomes and functional tests collected at baseline, together with the accelerometer-based physical activity data. If progress lags—based on the Goal Attainment Scaling goal, clinical assessments, and activity data—the patient is fast-tracked for a multidisciplinary rehabilitation assessment to integrate more intensive, vocational rehabilitation. The pathway continues until the patient has resumed contractual pre-operative working hours (full return to work).

Taken together, BAAS offers a concrete illustration of how the broader concept of participation-oriented recovery can be operationalized in hospital care. Its rigorous prospective evaluation will provide urgently needed evidence on whether a work-integrated pathway can deliver better and more timely participation outcomes and societal value compared with traditional, clinically focused models of post-hospital recovery.

Objectives and outline of the thesis

The BAAS work-integrated pathway for knee arthroplasty serves as the empirical test-bed. The PhD thesis examines whether the BAAS work-integrated pathway can help a deliberate shift from traditional, clinician-centered endpoints toward participation-oriented outcomes and thereby improve patient-centered recovery after hospital admission. Four complementary objectives are addressed:

1. Feasibility: Is BAAS deliverable in routine orthopedic practice and acceptable to professionals across medical and occupational domains?
2. Effectiveness – Does BAAS accelerate and increase return to work compared with care-as-usual?
3. Economic value – What are the healthcare, productivity and societal costs of BAAS and is there a positive return on investment?
4. Improvement – On which factors surrounding knee arthroplasty should we focus to further optimize BAAS?

Chapter 2 investigates whether four previously implemented peri-operative pathways on the orthopedic ward in Nij Smellinghe hospital (Joint Care, Function-tailored care, Fast-track, Prehabilitation) have led to optimization of more traditional in-hospital recovery outcomes such as length of stay, time to inpatient recovery of activities and percentage of patients discharged to their previous living situation. Given that these four changes focused on improving clinical outcomes, BAAS represented the next change, focusing on a participation outcome: return to work. Chapter 3 establishes whether the BAAS work-integrated pathway is feasible to evolve toward broader outcomes. Chapters 4–6 assess that proposition in a real-world BAAS cohort, by investigating effectiveness and return on investment of BAAS compared to care-as-usual. Chapters 7–9 evaluate where work-integrated clinical care, such as the BAAS work-integrated pathway, could improve by focusing on the right prognostic factors for return to work surrounding surgery. Finally, Chapter 10 synthesizes the accumulated evidence, delineating actionable steps for health-system leaders to mainstream participation-oriented, patient-centered recovery.

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CHAPTER

2

A stepwise transformation: description and outcome of perioperative procedures in patients receiving a total knee arthroplasty: a data-driven 11-year follow-up study

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Abstract

Aims: To investigate the impact of consecutive perioperative care transitions on in-hospital recovery of patients who had primary total knee arthroplasty (TKA) over an 11-year period.

Methods: This observational cohort study used electronic health record data from all patients undergoing preoperative screening for primary TKA at a Northern Netherlands hospital between 2009 and 2020. In this timeframe, three perioperative care transitions were divided into four periods: Baseline care (Joint Care, $n = 171$; May 2009 to August 2010), Function-tailored ($n = 404$; September 2010 to October 2013), Fast-track ($n = 721$; November 2013 to May 2018), and Prehabilitation ($n = 601$; June 2018 to December 2020). In-hospital recovery was measured using inpatient recovery of activities (IROA), length of stay (LOS), and discharge to preoperative living situation (PLS). Multivariable regression models were used to analyze the impact of each perioperative care transition on in-hospital recovery.

Results: The four periods analyzed involved 1,853 patients (65.9% female (1,221/1,853); mean age 70.1 years (SD 9.0)). IROA improved significantly with each transition: Function-tailored (0.9 days; $p < 0.001$ (95% confidence interval (CI) -0.32 to -0.15)), Fast-track (0.6 days; $p < 0.001$ (95% CI -0.25 to -0.16)), and prehabilitation (0.4 days; $p < 0.001$ (95% CI -0.18 to -0.10)). LOS decreased significantly in Function-tailored (1.1 days; $p = 0.001$ (95% CI -0.30 to -0.06)), Fast-track (0.6 days; $p < 0.001$ (95% CI -0.21 to -0.05)), and prehabilitation (0.6 days; $p < 0.001$ (95% CI -0.27 to -0.11)). Discharge to PLS increased in Function-tailored (77%), Fast-track (91.6%), and prehabilitation (92.6%). Post-hoc analysis indicated a significant increase after the transition to the Fast-track period ($p < 0.001$ (95% CI 3.19 to 8.00)).

Conclusion: This study highlights the positive impact of different perioperative care procedures on in-hospital recovery of patients undergoing primary TKA. Assessing functional recovery, LOS, and discharge towards PLS consistently, provides hospitals with valuable insights into postoperative recovery. This can potentially aid planning and identifying areas for targeted improvements to optimize patient outcomes.

Introduction

The number of patients diagnosed with knee osteoarthritis is growing globally,¹ with the prediction for the next decade that a significant number will require arthroplasty surgery. In the Netherlands, the number of patients receiving total knee arthroplasty (TKA) due to osteoarthritis has increased by 44% over the past 13 years, with a projected annual increase of 4.5%.^{2,3} TKA surgery has led to a 68% reduction in postoperative pain during activity (n = 30,046) and a 40% improvement in perceived health-related quality of life (n = 31,882).⁴⁻⁶

Surgery in general is considered to be a major physiological and psychosocial stressor, with potential risks of causing both reversible and irreversible consequences.⁷ People with a lower physiological reserve are at higher risk of responding inadequately to the demands of such a surgical stressor.^{7,8} Hospital-associated disability remains prevalent, particularly among older adults, even with a shorter length of stay (LOS).⁹ In this context, a drive for constant improvement of the perioperative programme has been observed, leading to the emergence of fast-track principles and prehabilitation programmes.^{6,10,11}

The objective of this study was to investigate the impact of three stepwise improvements in perioperative care with patients undergoing TKA surgery. The first transition went from Joint Care to a Function-tailored model of care, which emphasizes physical, social, and mental activation of patients. Next, a medical Fast-track pathway was added. In the last period, Prehabilitation was introduced for at-risk patients who were selected based on validated screening.^{12,13} The impact on in-hospital recovery of each of these care transitions was evaluated. We hypothesized that each of these transitions contributed to a faster inpatient recovery of activities (IROA), a shorter LOS, and a higher proportion of patients being discharged to their preoperative living situation (PLS).

Methods

This study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) and Reporting of Studies Conducted using Observational Routinely-collected Data (RECORD) guidelines.¹⁴ The checklist is available in the Supplementary Material.

Ethical approval

Ethical approval was obtained from NijSmellinghe Hospital's Medical Ethical Committee (MEC). The MEC determined that a full review was not required under the Dutch Medical Research with Human Subjects Law (reference ID: 16-107/JS/AB, 3 December 2013 and BK/AB/ID 17568, 1 February 2021). Additionally, this study adheres to the Medical Treatment Agreement Act¹⁵ and the General Data Protection Regulation Act.

Design, setting, and participants.

An observational cohort study was chosen to evaluate the impact of each step of additive improvements in TKA care on IROA, LOS, and discharge towards PLS. Between May 2009 and December 2020, all 1,853 patients with symptomatic osteoarthritis of the knee requiring TKA were included. The patients had opted for TKA surgery in our district hospital and all received a preoperative functional screening from a dedicated physiotherapist. No exclusion criteria were used for this study. The dataset included only patients undergoing TKA, so no patients who underwent unicompartmental knee or total knee revision surgery are included in the cohort. The preoperative functional screening with validated tools by a physiotherapist was standard care in our patients undergoing knee arthroplasty surgery.

Following approval from the MEC, the routinely collected medical data were obtained from the hospital's administration department. Population validation was conducted using all registries of healthcare activity code 190306 in conjunction with billing code 190306, representing TKA as defined by the Dutch Healthcare Authority.¹⁶ Figure 1 illustrates the pathway from accessing data in the healthcare process to its analysis, showcasing an example of final analysis on IROA.

Interventions

In 2009, baseline TKA care in our hospital was a programme called Joint Care, an in-hospital group-based rehabilitation programme with structured interventions based on postoperative days.¹⁷ The first transition was from Joint Care towards Function-tailored care, a cultural change that involved collectively training all medical and allied health professional staff to preoperatively advocate patients staying active, emphasizing early mobilization and the high likelihood of discharge home. Staff were also trained to improve patients' postoperative functional recovery by achieving functional milestones. The second transition involved implementation of Fast-track principles with Function-tailored care, through tailored anaesthesia protocols to facilitate rapid emergence, proactive pain management strategies, and nutritional management adaptations to

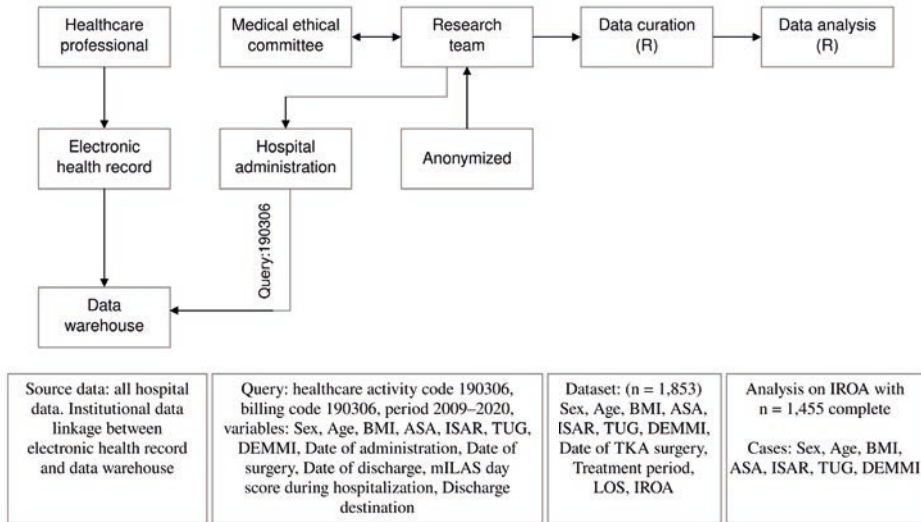


Figure 1: Flowchart of data from source to final analysis on inpatient recovery of activities (IROA). Abbreviations: ASA: American Society of Anesthesiologists grade; DEMMI: De Morton Mobility Index; ISAR: identification of seniors at risk; LOS: length of hospital stay; mLAS: modified Iowa Levels of Assistance Scale; TUG: Timed Up and Go test.

enhance early mobilization and rapid recovery. In the third transition, a validated risk stratification tool targeting inpatient functional recovery was used, followed by a prehabilitation programme aimed specifically at patients who are at risk of experiencing delayed physical functioning after surgery.^{12,13} To improve clarity, we have named the transition periods according to the most important theme: Joint Care (May 2009 to August 2010), Function-tailored (September 2010 to October 2013), Fast-track (November 2013 to May 2018), and Prehabilitation (June 2018 to December 2020). An overview on the global content of each of these is presented in Table 1. Further detailed information can be found in the Supplementary Material.

Measurements and variables

To evaluate each care period, we used routinely collected medical and functional data obtained from the hospital administration pertaining to all 1,853 patients who underwent TKA surgery, as depicted in Figure 1. All patients underwent preoperative functional screening conducted by a physiotherapist. Patients were screened for prospectively measured characteristics, including sex, age, BMI, American Society of Anesthesiologists (ASA) grade¹⁸, the identification of seniors at risk (ISAR) score¹⁹, Timed Up and Go test score (TUG), and de Morton mobility index (DEMMI) score.²⁰ These measures were used to account for the heterogeneity between patients in the different periods of care. Previous research has demonstrated that these measures have an independent influence on our outcome measures.^{13,17,21}

Table 1: Content of intervention periods of total knee arthroplasty care given from 2009 until 2020 and stages of the patient journey.

Patient journey	Joint Care (May 2009 to August 2010)	Function-tailored (September 2010 to October 2013)	Fast-track (November 2013 to May 2018)	Prehabilitation (June 2018 to December 2020)
Preoperative stage				
Screening and appointments	Functional screening,* medical screening, information meeting	Functional screening, medical screening, information module*	Functional screening, medical screening, information module	Functional screening, medical screening, information module, training period at home for patients at risk for delayed recovery*
Nutritional management	Fasted 12 hours before surgery	Fasted 12 hours before surgery	Preop 2 hours before surgery*	Preop 2 hours before surgery
Moment of surgery	According to hospital planning	According to hospital planning	According to hospital planning	According to patient's needs and preferences*
Preloading of pain medication	None	None	Gabapentin starting 3 days before surgery*	Gabapentin starting 3 days before surgery
Intraoperative stage				
Anaesthesia	Spinal (Bupivacaine 0.5%)	Spinal (Bupivacaine 0.5%)	Spinal (Bupivacaine 0.5%), local infiltration analgesia*	Spinal (Bupivacaine 0.5%), local infiltration analgesia
Surgical technique	Medial approach	Medial approach	Medial approach	Medial approach
Postoperative stage				
Postoperative pain medication	Patient-controlled analgesia, paracetamol, NSAIDs	Patient-controlled analgesia, paracetamol, NSAIDs	Gabapentin until 3 days after surgery,* paracetamol, NSAIDs, patient-controlled analgesia as rescue*	Gabapentin, paracetamol, NSAIDs, patient-controlled analgesia as rescue
Drain/catheter	Until 2 days postop	Removed in < 24 hours*	Removed in < 24 hours	Removed in < 24 hours
Start mobilization	After 24 hours	Within 4 hours*	Within 4 hours	Within 4 hours
Discharge planning	Time table and medical conditions	Functional and medical goal setting based on preop screening*	Functional and medical goal setting based on preop screening	Functional and medical goal setting based on preop screening
Projected discharge	5 days from day of surgery	mILAS score 0 achieved*	mILAS score 0 achieved	mILAS score 0 achieved

* Changes that were new in relation to baseline care.

Abbreviations: mILAS: Modified iowa levels of assistance scale; NSAID: non-steroidal anti-inflammatory drugs.

To assess the impact of each period after transition, we used the same outcome measures as our previous publication in 2015,¹⁷ including: 1) IROA, defined as the time in days from the day of surgery until the day when physical functioning was considered restored according to the modified Iowa Levels of Assistance Scale (mILAS) (score of ≤ 6); 2) LOS, defined as the number of days in hospital, including the day of surgery, until discharge; and 3) patients' discharge to PLS.^{17,19}

Statistical analysis

Descriptive statistics were calculated for patient characteristics, performance measures, and dependent variables. In the regression analysis of the outcomes, the diversity between patients related to age, BMI, ASA grade, TUG, and DEMMI was controlled for by using these variables. To test if the additively implemented changes in care actually improved outcomes, we applied post-hoc pairwise multiple comparisons to the consecutive periods.

The relation between each transition in care on IROA was analyzed with a Tobit regression model. The patients with incomplete functional recovery were discharged to a rehabilitation clinic or nursing home. They did not receive functional independence during hospital stay (mILAS < 6), and hence had missing values on IROA. These patients were of interest to us, because they were at risk of a delayed recovery of physical function after surgery.²¹ To keep these patients in the analysis, the missing values were treated as right-censored, set at seven days.

The relation between each transition in care and LOS was analyzed by a multivariable Poisson regression model. To find models that are optimal in predicting LOS, those that had minimum Akaike's Information Criterion (AIC) values were selected.²² Additionally, a sensitivity analysis using Cook's distance was conducted to assess the potential influence of extreme outlying cases on model outcomes. To further validate the robustness of conclusions from the model, bootstrapping with R = 2,000 replicates was conducted to verify the validity of the confidence intervals (CIs) for the estimated parameters of the multivariable model.

The relation between each transition and the proportion of patients returning to their PLS after hospital discharge was analyzed with univariable and multivariable logistic regression analysis. A multivariable analysis followed by minimum AIC model selection was performed to find the best predictive model for testing our expectations by multiple pairwise comparisons.²² To assess the sensitivity and robustness of our multivariable logistic regression model, Cook's distances were calculated for each patient. This enabled an examination of influential observations while validating the internal consistency and predictive strength of the multivariable model via bootstrapping with R = 2,000 replicates.

All statistical analysis was performed using the programming language R v. 4.1.1, along with the main R packages (R Foundation for Statistical Computing, Austria): foreign version 0.8-86, car version 3.1-2, multcomp version 1.4-25, MASS version 7.3-60, and AER version 1.2-10.²³⁻²⁶ Statistical significance was set throughout at $p \leq 0.05$.

Results

Baseline characteristics of the patients are provided in Table II. There were no statistically significant differences between the patient populations visiting our hospital during the four periods with regard to age ($F(3, 1,849) = 1.468$; $p = 0.222$). There were significant differences for BMI ($F(3, 1,841) = 3.519$; $p = 0.015$), ASA grade ($F(3, 1,825) = 15.19$; $p < 0.001$), TUG score ($F(3, 1,748) = 20.43$; $p < 0.001$), and DEMMI score ($F(3, 1,719) = 22.79$; $p < 0.001$).

Table II. Characteristics of all patients at preoperative screening and their postoperative recovery, separated over four periods of care.

Patient characteristic	Joint Care (2009 to 2010) n	Joint Care (2009 to 2010) Mean (SD)	Function-tailored (2010 to 2013) n	Function-tailored (2010 to 2013) Mean (SD)	Fast-track (2013 to 2018) n	Fast-track (2013 to 2018) Mean (SD)	Prehabilitation (2018 to 2020) n	Prehabilitation (2018 to 2020) Mean (SD)
Age, yrs	127	71.1 (8.4)	404	69.4 (9.6)	721	70.2 (8.9)	601	70.1 (8.8)
BMI, kg/m ²	127	29.9 (5.4)	399*	30.1 (5.0)	721	29.4 (4.6)	598*	29.1 (4.8)
ASA grade, I to IV	112*	2.0 (0.4)	403*	1.9 (0.5)	714*	2.1 (0.5)	600*	2.1 (0.5)
ISAR, 0 to 6 points	112*	1.2 (1.3)	397*	0.9 (1.0)	673*	0.7 (0.9)	508*	0.7 (0.8)
TUG, seconds	126*	12.4 (7.4)	397*	11.4 (5.8)	689*	9.3 (5.2)	539*	9.5 (5.2)
DEMMI, 0 to 100 points	111*	76.2 (17.6)	388*	76.5 (16.6)	682*	82.6 (14.6)	542*	83.6 (14.3)
IROA, days	85†	4.4 (0.9)	334†	3.5 (0.9)	663†	2.9 (1.0)	575†	2.5 (1.0)
LOS, days	127	5.2 (1.8)	382*	4.1 (1.1)	714*	3.5 (1.3)	601	2.9 (1.6)
Discharge destination, % PLS	127	69.0	382*	77.7	720*	91.6	598*	92.6

*Missing cases due to no traceable data in the patients' medical records.

†Missing cases due to patients who were not fully recovered, who were referred to a rehabilitation centre. ASA, American Society of Anesthesiologists; DEMMI, de Morton Mobility Index; IROA, time to inpatient recovery of activities; ISAR, identification of seniors at risk; LOS, length of hospital stay; PLS, preoperative living situation; SD, standard deviation; TUG, Timed Up and Go test.

The relationship between the implemented changes in care and IROA was investigated with a Tobit regression analysis using the explanatory variables sex, age, BMI, ASA grade, ISAR, TUG, and DEMMI. The results are presented in Table III. Post-hoc paired comparison showed that IROA (in days) decreased significantly after each transition by 0.9 days in the Function-tailored period ($p < 0.001$ (95% CI -0.32 to -0.15)), by 0.6 days in the Fast-track period ($p < 0.001$ (95% CI -0.25 to -0.16)), and by 0.4 days in the Prehabilitation period ($p < 0.001$ (95% CI -0.18 to -0.10)). The relationship between the implemented changes in care and LOS was analyzed with

a univariable and multivariable Poisson regression analysis. We used a minimum AIC model ($\Delta \text{AIC} = \text{AIC total model: } 5,496 - \text{min. AIC model: } 5,492.2 = 3.8$), in which the minimum AIC model is 3.8 points better at explaining the variability in the data compared to the total model, with the variables age, ASA grade, ISAR, TUG, and DEMMI. Visualization of the effects of the variables in the multivariable model with minimum AIC is presented in Figure 2. The Cook's distance revealed that the maximum influence exerted by any single data point on the model's coefficients or predictions for LOS was 0.058, signifying minimal influence on the model's outcomes. The results of these analyses are presented in Table IV.

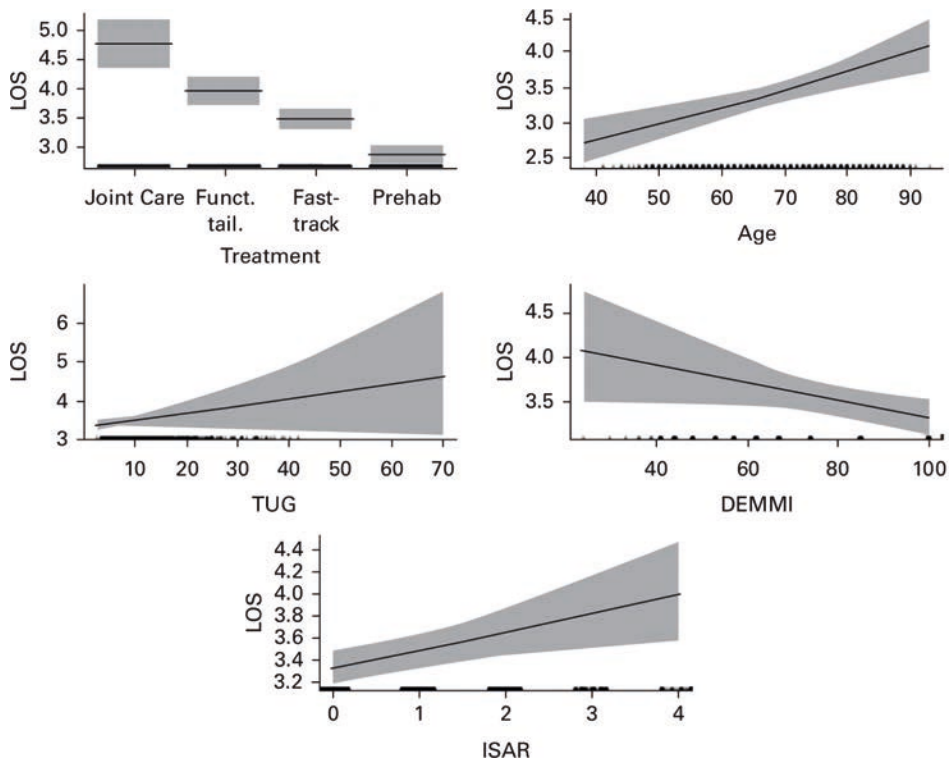


Figure 2

Bootstrap analysis ($R = 2,000$) confirmed the validity of model implications. Post-hoc paired comparison revealed that LOS decreased significantly after each phase of implementation: by 1.1 days in the Function-tailored period ($p = 0.001$ (95% CI -0.30 to -0.06)), by 0.6 days in the Fast-track period ($p < 0.001$ (95% CI -0.21 to -0.05)), and by 0.6 days in the Prehabilitation period ($p < 0.001$ (95% CI -0.27 to -0.11)).

Table III. Tobit regression analysis of inpatient recovery of activities, including correcting covariates and the periods Joint Care, Function-tailored, Fast-track, and Prehabilitation.

Variables	Estimate (95% CI)*	p-value
Sex	0.003 (-0.025 to 0.031)	0.825
Age	0.005 (0.003 to 0.007)	< 0.001
BMI	0.000 (-0.003 to 0.003)	0.955
ASA grade	0.024 (-0.006 to 0.054)	0.117
ISAR	0.030 (0.013 to 0.048)	< 0.001
TUG	0.009 (0.004 to 0.013)	< 0.001
DEMMI	-0.002 (-0.003 to -0.001)	0.005
Treatment period		
Function-tailored	-0.235 (-0.301 to -0.168)	< 0.001
Fast-track	-0.443 (-0.506 to -0.379)	< 0.001
Prehabilitation	-0.581 (-0.646 to -0.517)	< 0.001
Linear hypotheses†		
Function-tailored vs Joint Care	-0.235 (-0.315 to -0.154)	< 0.001
Fast-track vs Function-tailored	-0.208 (-0.252 to -0.164)	< 0.001
Prehabilitation vs Fast-track	-0.139 (-0.176 to -0.101)	< 0.001

*Multivariable Tobit regression model with the variables sex, age, BMI, ASA grade, ISAR score, TUG time, and DEMMI score (n = 1,455, 398 observations deleted due to missing data, 12 observations were right-censored to 7 days).

†Post-hoc paired comparison analysis.

ASA, American Society of Anesthesiologists; CI, confidence interval; DEMMI, de Morton Mobility Index; IROA, time to inpatient recovery of activities; ISAR, identification of seniors at risk; LOS, length of hospital stay; TUG, Timed Up and Go test.

Table IV. Univariable and multivariable Poisson regression analysis of length of stay, including correcting covariates and the periods Joint Care, Function-tailored, Fast-track, and Prehabilitation.

Variables	Univariable relationship* Estimate (95% CI)	Univariable relationship* p-value	Multivariable model† Estimate (95% CI)	Multivariable model† p-value
Sex	0.96 (0.91 to 1.01)	0.081		
Age	1.01 (1.01 to 1.02)	< 0.001	0.01 (0.00 to 0.01)	< 0.001
BMI	1.00 (1.00 to 1.01)	0.192		
ASA grade	1.15 (1.09 to 1.21)	< 0.001	0.05 (-0.01 to 0.11)	0.091
ISAR	1.14 (1.11 to 1.17)	< 0.001	0.05 (0.02 to 0.08)	0.004
TUG	1.02 (1.02 to 1.03)	< 0.001	0.00 (0.00 to 0.01)	0.149
DEMMI	1.00 (0.99 to 0.99)	< 0.001	0.00 (-0.01 to 0.00)	0.034
Treatment period				
Function-tailored			-0.18 (-0.28 to -0.08)	< 0.001
Fast-track			-0.31 (-0.40 to -0.21)	< 0.001
Prehabilitation			-0.50 (-0.60 to -0.40)	< 0.001
Linear hypotheses‡				
Function-tailored vs Joint Care	-0.25	< 0.001	-0.18 (-0.30 to -0.06)	0.001
Fast-track vs Function-tailored	-0.16	< 0.001	-0.13 (-0.21 to -0.05)	< 0.001
Prehabilitation vs Fast-track	-0.18	< 0.001	-0.19 (-0.27 to -0.11)	< 0.001

*Univariable relationship between the variables and LOS.

†Multivariable Poisson regression model (n = 1,601, 252 observations deleted due to missing data) with the variables age, ASA grade, ISAR score, TUG time, and DEMMI score. A minimum AIC model is used ($\Delta \text{AIC} = \text{AIC total model} - \text{minimum AIC model} = 5496 - 5492.2 = 3.8$).²²

‡Post-hoc paired comparison analysis.

ASA, American Society of Anesthesiologists; CI, confidence interval; DEMMI, de Morton Mobility Index; IROA, time to inpatient recovery of activities; ISAR, identification of seniors at risk; LOS, length of hospital stay; TUG, Timed Up and Go test.

The relation between the implemented changes in care and discharge towards PLS was analyzed with a univariable and multivariable logistical regression analysis. The results of these analyses are presented in Table V.

Table V. Univariable and multivariable logistic regression analysis of return to preoperative living situation using correcting covariates and the periods Joint Care, Function-tailored, Fast-track, and Prehabilitation.

Variables	Univariable model* Estimate	Univariable model* OR (95% CI)	Univariable model* p-value	Multivariable model† Estimate	Multivariable model† OR (95% CI)	Multivariable model† p-value
Sex	0.69	1.99 (1.44 to 2.77)	< 0.001			
Age	-0.13	0.88 (0.86 to 0.90)	< 0.001	-0.10	0.90 (0.88 to 0.93)	< 0.001
BMI	-0.00	1.00 (0.97 to 1.02)	0.738			
ASA	-0.92	0.40 (0.30 to 0.53)	< 0.001			
ISAR	-0.84	0.43 (0.37 to 0.50)	< 0.001	-0.23	0.79 (0.66 to 0.96)	0.017
TUG	-0.19	0.83 (0.81 to 0.85)	< 0.001	-0.07	0.93 (0.89 to 0.97)	< 0.001
DEMMI	0.08	1.09 (1.07 to 1.10)	< 0.001	0.03	1.03 (1.01 to 1.05)	< 0.001
Treatment period						
Function-tailored	0.47	3.48 (1.03 to 2.49)	0.036	0.58	1.79 (1.00 to 3.18)	0.049
Fast-track	1.62	11.02 (3.19 to 8.00)	< 0.001	1.60	4.97 (2.73 to 9.01)	< 0.001
Prehabilitation	1.76	12.66 (3.58 to 9.46)	< 0.001	1.90	6.68 (3.51 to 12.80)	< 0.001
Linear hypotheses‡						
Function-tailored vs Joint Care	0.47		0.098	0.58		0.134
Fast-track vs Function-tailored	1.15		< 0.001	1.02		< 0.001
Prehabilitation vs Fast-track	0.14		0.855	0.30		0.571

*Univariable logistic regression model (n = 1,852), relationship between each implemented change and discharge towards home in comparison with the Joint Care period.

†Multivariable logistic regression model (n = 1,622, 230 observations deleted due to missing data) with the variables age, ISAR score, TUG time, and DEMMI score. A minimum AIC model is used (Δ AIC = AIC total model: 832.69 - min AIC model: 829.18 = 3.51).²²

‡Post-hoc paired comparison analysis.

ASA, American Society of Anesthesiologists; CI, confidence interval; DEMMI, de Morton Mobility Index; IROA, time to inpatient recovery of activities; ISAR, identification of seniors at risk; LOS, length of hospital stay; OR, odds ratio; TUG, Timed Up and Go test.

There was a univariable relationship between the periods in care and the percentage of patients discharged towards their PLS out of 1,852. After each transition, the percentage of patients with a referral towards their PLS increased from 69% (88/127) to 77% (297/387) in the Function-tailored period, 91.6% (660/720) in the Fast-track period, and 92.6% (554/598) in the Prehabilitation period. Further investigating the relationship between the periods of care and the percentage of people discharged towards their PLS, a logistic regression

analysis and a multivariable model with a minimum AIC (Δ AIC = total model: 832.69 – min. AIC model: 829.18 = 3.51) with the (significant) variables age, ISAR, TUG, and DEMMI was used.²² Visualization of the effects of the variables in the multivariable model with minimum AIC is presented in Figure 3. Bootstrapping (R = 2,000) confirmed the results of the model.

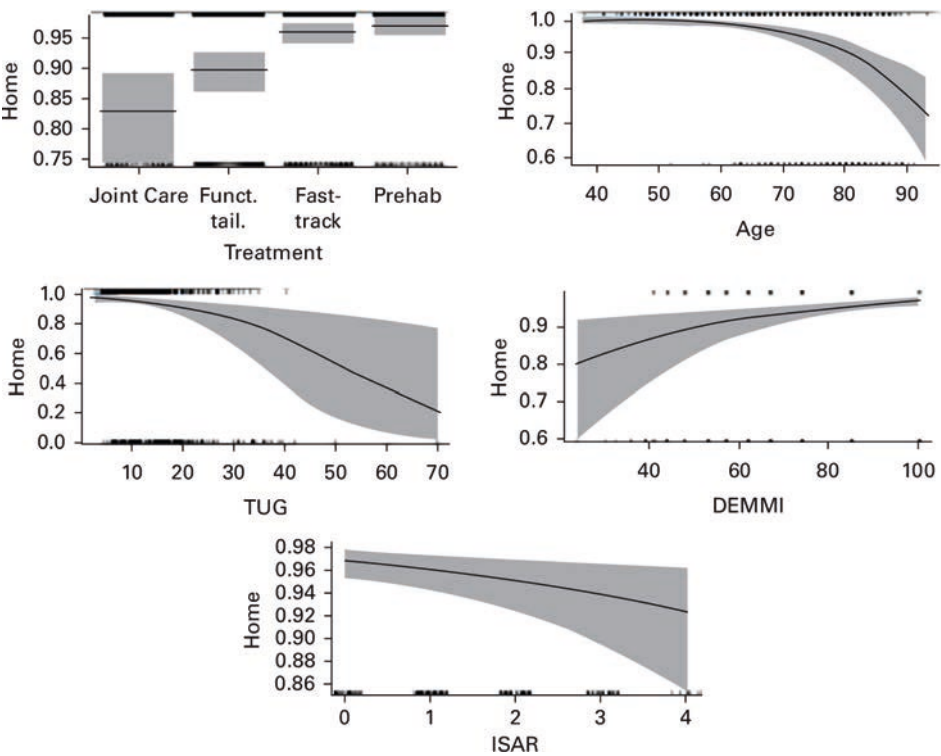


Figure 3

To ensure model robustness, Cook's distance was performed, revealing a maximum value of 0.029 over all patients. Post-hoc paired comparison revealed that the percentage of patients discharged towards their PLS changed significantly ($p < 0.001$ (95% CI 3.19 to 8.00)) from the Function-tailored (77.7%) to the Fast-track period (91.6%). From the Joint Care (69%) to the Function-tailored period ($p = 0.172$ (95% CI -0.16 to 1.25)) and the Fast-track to the Prehabilitation period (92.6%) ($p = 0.460$ (95% CI -0.29 to 0.98)), no significant changes were found.

Discussion

This study presents the first investigation into the impact of three different care transitions on in-hospital recovery in patients undergoing TKA surgery over an 11-year period in our institution. Our study takes a comprehensive approach by examining multiple care transitions over an extended duration while focusing on various aspects of in-hospital recovery. The results demonstrate consistent improvements in IROA and LOS and increased discharge towards PLS.

A strength of this study is the use of three independent outcome variables to measure in-hospital recovery, unlike previous studies that focused solely on the influence of a single care transition.²⁷⁻³⁰ This comprehensive approach allowed assessment of multiple aspects of patients' recovery, including the reduction in hospitalization time, improvements in the speed of achieving functional capability for returning home, and the progress in patients' discharge towards their PLS. By adopting this patient-centred perspective, our study focused on the impact of perioperative care transitions from the patient's point of view. Another strength of the study is that it included data from all patients who underwent primary TKA surgery and received a preoperative functional screening from a physiotherapist. Our patient population closely matches the demographics of patients who underwent TKA included in the National Arthroplasty Registries, with similar characteristics in terms of sex, age, ASA grade, and BMI.⁴

There are some limitations to consider. Despite our methodological focus on discrete care transitions, necessitating timestamped periods to monitor the changes implemented in perioperative care, our study encountered limitations in exploring temporality due to episodic data collection. The current design makes time-series analyses impossible. Nevertheless, our approach yielded significant insights into the direct impact of the care transitions on inpatient recovery. While acknowledging that transitions in perioperative care constitute continuous learning processes, characterized by iterative cycles with anticipated gradual improvements, our data show a consistent improvement in the speed of IROA and reduction in LOS in each period of implemented care.³¹ Another area of potential improvement is the measurement of LOS in days. LOS following TKA procedures is decreasing, it might be more appropriate to consider measuring LOS in hours, as suggested by some studies.^{32,33} This approach to improvements in LOS would be potentially more accurate and give a stronger statistical result. Furthermore, although our patient characteristics demonstrate similarities to the general population of TKA patients in the Netherlands, we observed that in the later periods our patients had better TUG and DEMMI scores.⁴ Functional preoperative status has been shown to influence

in-hospital recovery.⁶ Even small improvements in TUG score correlate with an improved speed of IROA.¹² In our multivariable analysis, we included TUG and DEMMI as controlling variables in our models for in-hospital recovery. Regarding the differences observed in BMI and ASA grade, their values in the four time periods in Table II indicate these were very small.

Based on the findings of our study, we advocate for the continuous monitoring of in-hospital recovery across various outcomes, including IROA, LOS, and discharge towards PLS. Our study's transitions demonstrated significant improvements in these outcomes. Over an 11-year period, the mean IROA went from 4.4 days to 2.5 days, the mean LOS went from 5.2 days to 2.9 days, and discharge towards PLS increased from 69% to 92.6%. Routine measurement of these outcomes enables hospitals to identify areas for improvement and implement targeted interventions to optimize patient outcomes. Safe and validated patient discharge can be based on the medical situation and IROA. If LOS, IROA, and discharge towards PLS can be predicted for the majority of patients, it provides a logistical advantage in planning. This predictive capability may assist hospitals in effectively using their limited resources in the future. Finally, we recommend hospitals take into account the functional perioperative status of patients and use appropriate controlling variables when analyzing in-hospital recovery.

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CHAPTER

3

**Implementation of Back At Work
After Surgery (BAAS): a feasibility
study of an integrated pathway
for improved return to work
after knee arthroplasty**

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Abstract

Purpose: Optimizing return to work after knee arthroplasty is becoming more important because of the growing incidence of KA among workers and poor return-to-work outcomes. The purpose of this study is to investigate the feasibility of Back At work After Surgery (BAAS): an integrated clinical pathway for return to work after knee arthroplasty.

Method: Working patients who received unicompartmental knee arthroplasty (UKA) or total knee arthroplasty (TKA) between January 2021 and November 2021, younger than 65 years and motivated to return to work were eligible to participate. Feasibility was investigated on five domains: reach, dose delivered, dose received, fidelity and patients' attitudes. These outcomes were obtained by a patient-reported questionnaire and an interview with the occupational case manager and medical case manager.

Results: Of the eligible 29 patients, 11 were willing to participate (response rate 38%). The dose delivered was between 91 and 100%, except information given about return to work from the orthopaedic surgeon which was 18%. The dose received was 100%. For fidelity, case managers reported nine shortcomings for which five solutions were mentioned. In terms of patients' attitude, all patients were satisfied and one patient mentioned an improvement.

Conclusions: In terms of reach, participation was low: only 38%. The BAAS clinical pathway seems feasible based on dose delivered, dose received, fidelity and patient attitudes. The next step is to assess the effectiveness of the BAAS clinical pathway for return to work.

Introduction

For patients, return to work (RTW) after knee arthroplasty (KA) is becoming more important due to the growing incidence of KA, especially among patients of working age¹⁻⁵. Although pain relief and knee function are satisfactory after KA, RTW among patients is relatively low, about 50% within 6 months after KA⁶, and 68% do not return to work after 2 years.⁷

A closer collaboration between professionals in surgical care (e.g., orthopaedic surgeons, physical therapists) and occupational care (e.g., occupational physicians) might improve RTW.⁸ Unfortunately, proven effective interventions are not available yet for these patients.^{9,10}

We developed Back At work After Surgery (BAAS): an integrated clinical pathway for improved RTW after KA. This newly designed pathway follows the recommendations of the clinical guideline to optimise work participation by timely combination of medical and occupational care.¹¹ To the best of our knowledge, this is the first initiative to evaluate the feasibility of work-directed care among patients receiving KA.

Method

Study design and setting

A single centre study was performed with permission of the medical ethical committee of Nij Smellinghe hospital (reference ID: 17050/ JvE/AB) and described using the STROBE statement.¹² KA was performed by three of the five orthopaedic surgeons in this regional hospital.

Participants

The following are the patient eligibility criteria: (1) being scheduled for UKA or TKA due to knee osteoarthritis between January and November 2021; (2) having paid work; and (3) willing to fully RTW. Exclusion criteria were (1) receiving another surgical intervention within 1 year; (2) having a major mental disorder; (3) insufficient fluency in Dutch; or (4) not willing to receive physical therapy in Nij Smellinghe hospital. Eligible patients were informed by telephone about the study and received an information letter, informed consent and an infographic of the BAAS clinical pathway at home (Appendix I). Patients were called 1 week later to answer any additional questions about the study and were asked if they wanted to participate by signing the informed consent.

Intervention: The BAAS clinical pathway

The orthopaedic surgeon preoperatively provided information about time to RTW and prognostic factors for delayed RTW (Figure 1)^{13,14} and recommended that the patient consult the occupational physician before surgery. Next, the patient was referred to the occupational case manager (OCM, occupational assessor) to compile a report of beneficial and limiting factors regarding RTW after KA.

Next, the patient was referred to a MCM for a preoperative examination to address the patient's expectations and set a benchmark for physical functioning.¹⁵ The patient also filled in questionnaires and performed three tests to evaluate functioning (Table 1 and Figure 1).^{7,16-21} Moreover, the patient was given information about the perioperative care and received an accelerometer (PAM 2.0) and access to the Atris platform to assess the movement data (Peercode B.V.).²² A week later, the MCM called the patient to discuss the physical activity assessed by the accelerometer and gave advice regarding the preferred physical preparation, like practicing to walk with an aid and trying to adhere to the World Health Organization's activity guideline.^{23,24} The findings of the preoperative examination were used as baseline measurements for goalsetting in the postoperative rehabilitation and, not as an outcome for this feasibility study. During the hospitalisation, the patients received care according to the KA fast-track principles.²⁵

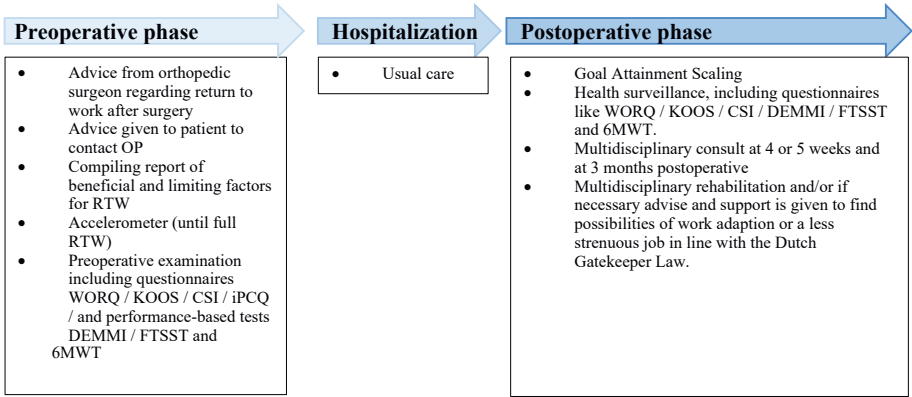


Figure 1: The BAAS clinical pathway. Abbreviations: 6MWT=6-min walk test, CRT=Chair Rise Time, CSI: Central Sensitization Inventory, DEMMI=de Morton Mobility Index, FTST: Five Time Sit to Stand, iPCQ=iMTA Productivity Cost Questionnaire, KOOS=Knee Osteoarthritis Outcome Score, OP=occupational physician, RTW=RTW, WORQ=Work, Osteoarthritis and Joint-Replacement Questionnaire

Postoperatively, the patient received physical therapy according to the Royal Dutch Society for Physiotherapy guideline, starting sessions twice a week.²⁶ The first sessions were at the patient's home to train activities of daily living, such as climbing stairs. These sessions started 24–48 h after discharge from the hospital until about week 4. Next, physical therapy was once or twice a week, depending on the patient's

needs, at the outpatient facility within Nij Smellinghe hospital. Goals shifted from activities of daily living to activities necessary for RTW. Goals were formally monitored every 6 weeks by Goal Attainment Scaling (GAS, Figure 1). Progress was evaluated by questionnaires (WORQ, KOOS, and CSI) and functional tests (DEMMI, FTSST and 6MWT) every 6 weeks and accelerometry on a weekly basis (Figure 1). Stop criteria were full RTW with a maximum follow-up of 2 years. A multidisciplinary consult (MDC) was held the fourth or fifth week after KA. The patient, the physical therapist, MCM, OCM and occupational physician were invited and the progress in recovery was discussed including the RTW plan according to the Dutch Gatekeeper Improvement Act (Figure 1). If the patient had a job which he likely could not return to (e.g., because of high knee demands), the possibility of work adaptations or even the topic of finding a less strenuous job were discussed (Figure 1). The MDC was continued if indicated. If, after 3 months, a delayed recovery was seen based on patient's experience, the measured data and the expert opinions of MCM, OCM and occupational physician, the patient was referred to a multidisciplinary rehabilitation assessment (Figure 1). Here, the patient was examined by a rehabilitation physician, occupational specialist, physical therapist and psychologist to assess barriers for delayed RTW and the patient's eligibility for an interdisciplinary vocational rehabilitation programme. If eligible, the patient then received this programme.²⁷

Table 1: Questionnaires and functional tests used to measure recovery

	Measures	Total score	Lower score indicates
Questionnaires			
Work, Osteoarthritis and Joint-Replacement Questionnaire (WORQ)	Thirteen 0-4 scale questions	0-100 scale total score	More disability in work-related and knee demanding activities
Knee Injury and Osteoarthritis Outcome Score (KOOS)	Thirteen 0-4 scale questions regarding work.	0-100 scale total score in five domains (KA related symptoms, pain, activities, sport participation and quality of life).	Less experienced disabilities in given domains.
Central Sensitization Inventory (CSI)	Twenty-five 0-4 scale questions	0-100 scale total score	Less chance of developing central sensitization related disabilities.
iMTA Productivity Cost Questionnaire (iPCQ)	Eleven questions regarding health and work	-	-
Functioning testing			
de Morton Mobility Index (DEMMI)	Eleven 0-1 and four 0-2 scale questions	0-100 scale total score	Less able to perform mobility skills
Five Time Sit to Stand Test (FTSST)	Time in seconds	Time in seconds	Less able to perform mobility skills
6-minute walk test (6MWT)	Time in seconds	Time in seconds	Less able to perform mobility skills

Feasibility outcomes

To assess feasibility, five outcomes were analysed: reach, dose received, dose delivered, fidelity and patient attitudes.²⁸ To assess reach, the degree of participation by the patients, occupational physicians and employers was analysed. To assess dose delivered, the proportion of the intervention that was delivered to the participants by orthopaedic surgeons, OCM and MCM was analysed. For dose received, exposure and usage of the intervention components was measured using a self-reported questionnaire filled in by the patients after they fully returned to work or 6 months after surgery (Appendix II).²⁹ To assess fidelity, an interview was held with the MCM and OCM by a third author (PK). For each patient, it was discussed whether the intended care was given as planned. Lastly, patient attitudes were measured using a self-reported questionnaire about the received care (Appendix II).

Sample size

We aimed to include 20 consecutive patients. This number was based on expectations that these 20 patients secure enough variability to determine whether the BAAS clinical pathway is feasible for all eligible patients with KA. To assess variability, prognostic factors for RTW of each patient were described, including preoperative sick- leave duration, body mass index and physical demands of the job.¹³

Statistical methods

Patient characteristics were described with median and interquartile range (IQR). Primary outcomes (reach, dose delivered, dose received, fidelity and patient attitudes) were described. Data were analysed using SPSS version 26.1.

Results

Participants

In the study period, 249 patients received a TKA or UKA and 80 were younger than 65 years. Fifty-one patients did not meet the inclusion or exclusion criteria, and 29 patients were asked to participate. 11 agreed to participate. The remaining 18 patients were not willing to participate due to long travel distance to the hospital (Figure 2).

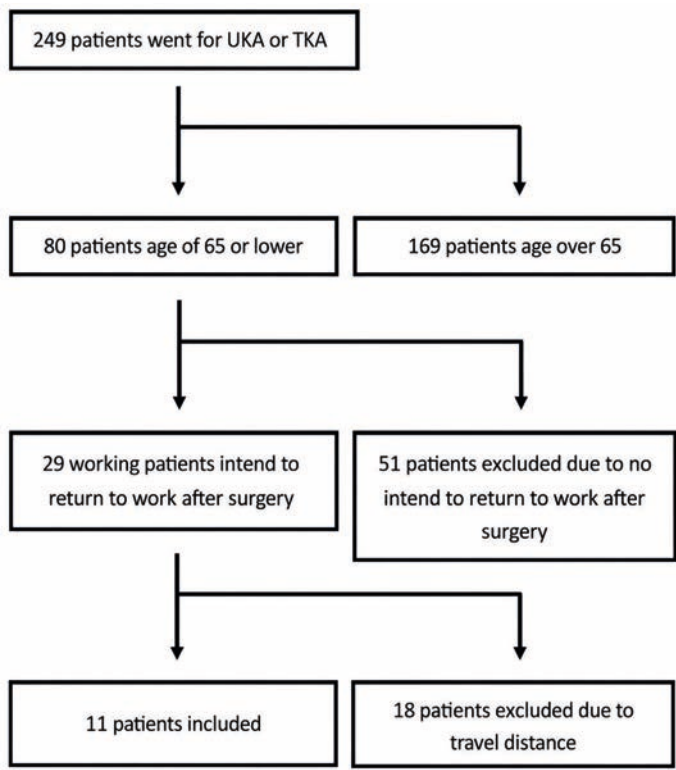


Figure 2: Flowchart of in- and exclusion. TKA, total knee arthroplasty; UKA, unicompartmental knee arthroplasty

Descriptive data

Of the 11 participants, the median age was 59 years, seven were female, and eight received TKA (Table 2). All patients fully returned to work within the first year, on average after 14 weeks after KA. One patient switched to another employer and started in a less demanding job. One patient was seen for a multidisciplinary rehabilitation assessment.

Table 2: Preoperative patient characteristics for participants in the Back At work After Surgery (BAAS) clinical pathway

	Median [Q1-Q3] [†] or number (percentage)*	Missing data (percentage)
Age[†]	59 [57-60]	0
Sex[‡]		0
• male	4 (36%)	
• female	7 (64%)	
Surgery[‡]		0
• UKA	3 (27%)	
• TKA	8 (73%)	
Length of stay (days)[†]	2 [2-2.5]	0
Number of patients reported preoperative sick leave > 2 weeks*	1 (9%)	0
Knee demanding work[‡]		0
• Low	2 (18%)	
• Medium	4 (36%)	
• High	5 (45%)	
Level of education[‡]		0
• Low	5 (45%)	
• Medium	3 (27%)	
• High	3 (27%)	
Functioning[†]		
• DEMMI (range 0-100)	85 [85-100]	2 (18%)
• 6 MWT	407 [397-449]	2 (18%)
• 5 STST	11.4 [10.3-12.7]	2 (18%)
Patient reported outcomes[†]		
• CSI (range 0-100)	23 [16.5-31.5]	1 (9%)
• KOOS		1 (9%)
o Symptoms (range 0-100)	42.9 [33.9-51.8]	
o Pain (range 0-100)	47.2 [38.9-50]	
o Activities (range 0-100)	57.4 [52.2-64.0]	
o Sport participation (range 0-100)	5 [0-17.5]	
o Quality of life (range 0-100)	18.8 [6.3-28.1]	
• WORQ (range 0-52)	42 [36.5-58.7]	1 (9%)
Return to work[†]		
• Weeks to start return to work	6.4 [6-8.1]	0
• Weeks to fully return to work	12.4 [9.8-14.4]	0

[†] = Numeric variables, [‡] = categorical variables. Abbreviations: 5 STST: 5 time sit-to-stand test, 6MWD = 6 minute walking test, CSI = Central Sensitization Inventory, DEMMI = de Morton Mobility Index, KOOS: Knee Osteoarthritis Outcome Score, WORQ = Work, Osteoarthritis and joint-Replacement Questionnaire; TKA = Total Knee Arthroplasty; UKA = Unicompartmental Knee Arthroplasty.

Table 3: Feasibility outcomes of the Back At Work after Surgery (BAAS) clinical pathway

	Number (%)
Reach	
◇ Number of patients who met inclusion criteria	29 (100)
◇ Number of patients included	11 (38)
◇ Number of cases where occupational physician was willing to participate	11 (100)
◇ Number of cases where employer was willing to participate	11 (100)
◇ Number of cases where OCM was involved	11 (100)
◇ Number of cases where MCM was involved	11 (100)
Dose delivered (OS/MCM/OCM/OP/MDR)	
◇ Information return-to-work from orthopedic surgeon	2 (18)
◇ Advice given to contact occupational physician before surgery	10 (100)
◇ Invitation sent for preoperative screening by MCM	10 (91)
o Set work-related goal before surgery	10 (91)
◇ Physical therapy received until full return to work	11 (100)
◇ Contact OCM	11 (100)
o Reach out before surgery	4 (36)
o Reach out after surgery	7 (64)
◇ Multi-disciplinary consult organized	11 (100)
◇ Accelerometer and information about usage was given	11 (100)
◇ Patients seen for quick scan before IVR	1 (100)
Dose received (patients)	
◇ Information return-to-work from orthopedic surgeon	2 (100)
◇ Contact with occupational physician	10 (100)
o Start before surgery	3 (30)
o Start after surgery	10 (100)
◇ Preoperative screening by MCM	10 (100)
o Set work-related goal before surgery	10 (100)
◇ Physical therapy received until full return to work	11 (100)
◇ Contact OCM	11 (100)
o Before surgery	2 (50)
o After surgery	10 (91)
◇ Multi-disciplinary consult	11 (100)
◇ Contact employer about return-to-work	10 (100)*
o Before surgery	3 (27)
o After surgery	10 (100)*
◇ Accelerometer	11 (100)
o Worn daily	11 (100)
Fidelity	
◇ Number of difficulties mentioned by OCM and MCM	9
◇ Number of improvements mentioned by OCM and MCM	5
Patients' attitude	
◇ Patient satisfied	11 (100)
◇ Improvements mentioned	1 (9)

Aberrations: MCM = medical case manager, OCM = occupational case manager, IVR = interdisciplinary vocational rehabilitation, OS = orthopedic surgeon, OP = occupational physician.

Feasibility

All patients completed the feasibility questionnaire (Table 3). In terms of reach, 38% of the invited patients decided to participate. Regarding dose delivered, the orthopaedic surgeons informed patients only two times (18%) about RTW. All patients received the intended care. One patient did not have contact with an occupational physician and did not have contact with the employer about RTW. This was due to the fact that this patient was self-employed. In terms of fidelity, seven shortcomings in care were reported. For these shortcomings in care, OCM and MCM mentioned five possible improvements (Table 4). Finally, all patients mentioned being satisfied with the BAAS clinical pathway. One patient was dissatisfied that the orthopaedic surgeon had not mentioned the high risk of no RTW due to his high knee-demanding work.

Table 4: Shortcomings and solutions mentioned by medical and occupational case managers

Shortcomings	Solutions
• In multiple cases, it was hard to get in contact with the occupational physician (4 out of 11) or employer (3 out of 11); • In three cases, the communication between OCM and MCM was not optimal given that the MCM was not informed when the report was finished or the OCM was not kept up to speed on cases regarding the RTW process; • The report made by OCM often came after surgery instead of before surgery (9 out of 11). This was due to the variability between the long waiting time before surgery during the SARS-COVID-19 outbreaks in the Netherlands and sudden short waiting times when surgery was possible to perform after the outbreak periods; • The OCM had a hard time figuring out which patient had fully returned to work and therefore which cases could be closed; • In one case, an occupational physician was not involved because the patient was self-employed and had no contract with an occupational physician or health service. Therefore, no occupational physician was present during the RTW; • Two patients went on holiday in the RTW period and therefore the rehabilitation and RTW process was postponed. This may have led to a longer RTW period; • The report of the OCM was not always up to date given that one patient was fired during the RTW period and one patient switched jobs before surgery while the report from OCM was already compiled, which delayed or complicated RTW;	• Compiling an information letter regarding the BAAS clinical pathway, which is sent to the OP and employer to improve communication with OP and employers; • In case an OP is not involved, the OCM and MCM will advise the patient on RTW; • Investigate whether employers can join the MDO if patients provide informed consent regarding discussing their work-related disabilities; • Organize a meeting every two weeks between OCM and MCM to discuss progress to improve communication between OCM and MCM; • Announce new patients to OCM directly after signing informed consent and implement a maximum period of 20 days between announcement and finishing the OCM report.

Aberrations: MCM = medical case manager, OCM = occupational case manager, OP = occupational physician, RTW = return to work.

Discussion

Key results

The BAAS clinical pathway appeared to be feasible in terms of dose delivered, dose received, fidelity and patients' attitudes. The reach appeared low in comparison to other feasibility studies among patients receiving orthopaedic care reporting data about 63%, 59% and 30%.³⁰⁻³² Our reach was 38%. This low reach was mainly due to the long travel distance to the hospital for physical therapy.

Interpretation

To increase reach, we suggest giving the physical therapy care from primary care physical therapists nearby the patient's home. This is also in line with the right care in the right place.³³ To increase the dose delivered, we advise training the orthopaedic surgeons to inform patients better about RTW and relevant prognostic factors, in line with recent studies.^{13,14,34} Future studies should investigate whether these measures indeed improved the feasibility.

Generalisability

The BAAS clinical pathway seems feasible within the Dutch social security and care systems. Further research is needed to assess the effectiveness on RTW. This study will be performed with a second hospital in the Netherlands to overcome any bias introduced by the clinical involvement of the primary researcher. In comparison to other studies among working-age patients with KA, the present patient characteristics were similar in terms of age, sex and educational level.^{6,14} An important prognostic factor for RTW for patients with KA are the physical job demands.¹⁴ Despite the low number of participants, the job demands ranged from low knee-demanding desk work to high knee-demanding work as a mechanic in which RTW appeared not possible. Lastly, the primary investigator fulfilled the roll of MCM. Thus, the expertise regarding RTW after KA might be higher than average. Therefore, future MCMs in other hospitals and clinics should be trained before implementing the BAAS clinical pathway. For the OCM, external validity is covered by using a service available nationwide due to the Dutch Gatekeeper Improvement Act.

Strengths and limitations

The BAAS clinical pathway is, to the best of our knowledge, the first clinical pathway to focus on RTW as the main outcome after KA.^{9,10} Unfortunately, no data were available on the feasibility or effectiveness of the Occupational advice for Patients undergoing Arthroplasty of the Lower limb.³⁵ Important similarities between OPAL and our pathway are an interdisciplinary approach and patient-

centred care. This is in line with the clinical guidance of Daley and colleagues on work participation.¹¹ They advised a timely combination of medical rehabilitation and occupational RTW care, including the use of self-reported and performance-based measures. In the Netherlands, another intervention was evaluated for working-age patients with KA, aiming at improved RTW, namely the ACTIVE trial.^{36,37} This intervention combines referral to a case manager in the hospital or clinic and rehabilitation with personalised goals and eHealth. In contrast with the BAAS clinical pathway, the case manager in the ACTIVE trial does not actively enhance cooperation or communication between patient, employer, OCM and the other healthcare professionals.

This study had two important limitations. First, the number of participating patients did not reach 20, but only 11. This was mainly due to restrictions in number of KA in the hospital, related to the SARS-COVID-19 pandemic. Secondly, the willingness of primary physical therapy settings to participate in the present BAAS pathway instead of physical therapy given from the hospital is not investigated. Future studies should show whether this is feasible.

Acknowledgements

Special thanks to Bert Schmaal for making this work possible and the patients who participated in the feasibility study. This project was made possible by funding from a.s.r. Insurances.

Conflict of interest

All authors declare that they have no conflicts of interest.

Ethical statement

Our study was performed in accordance with the declaration of Helsinki and Directive 95/46/EG of the European Union regarding data protection. According to Dutch law, research with anonymised care data acquired by the physiotherapist treating the patient does not require approval from a medical ethical committee and is not subjected to a procedure for informed consent applied by the hospital. This standpoint was confirmed by the ethical committee of Nij Smellinghe hospital with respect to this particular study (reference ID: 17050/JvE/AB).

Author contributions

All authors have made: (1) Substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; (2) Been involved in drafting the manuscript and revising it critically for important intellectual content; (3) Given final approval of the version to be published; and (4) Agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

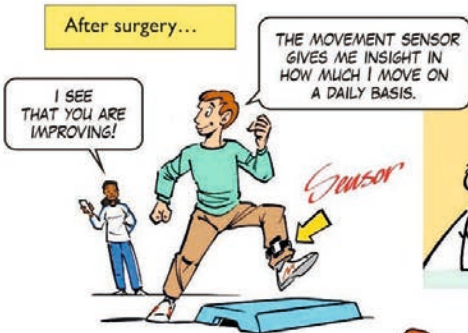
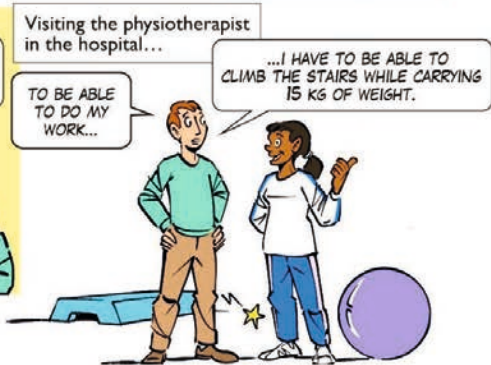
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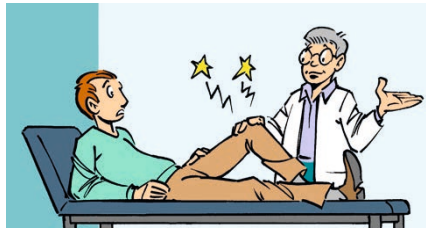
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Appendix I - Comic of the Back At work After Surgery (BAAS) clinical pathway

Back At work After Surgery (BAAS)



Appendix II – Self reported questionnaire



3

Questionnaire Back at work after surgery

1. Before and after surgery you spoke to an orthopedic surgeon. What did he or she told you regarding return to work?

- ☐ The orthopedic surgeon did not mention anything about return to work
- ☐ The orthopedic surgeon did mention the current study with the pupose of increasing the chance of early return to work after surgery.
- ☐ Other, namely: Klik hier als u tekst wilt invoeren.

2. Did you speak to an occupational physician before or after surgery?

- ☐ I had contact with an occupational physician before and after surgery
- ☐ I had contact with an occupational physician before surgery
- ☐ I had contact with an occupational physician after surgery
- ☐ I did not have contact with an occupational physician skip question 3

3. What topics did you discuss with your occupational physician?

- ☐ The occupational physician spoke with me about expectations regarding return to work after surgery.
- ☐ The occupational physician spoke with me about the possibilities of adjustment which can be made at work to enhance return to work after surgery.
- ☐ The occupational physician spoke with me about which factor regarding work need special attention to enhance return to work after surgery.
- ☐ Other, namely: Klik hier als u tekst wilt invoeren.

4. Did You have a consult with a physical therapist within the hospital?

- ☐ Yes, during this meeting we set a work related treatment goal.
- ☐ Yes, during this meeting we did not set a work related treatment goal.
- ☐ No

5. Did you receive physical therapy until you had fully returned to work?

- ☐ Yes
- ☐ No
- ☐ Other, namely: Klik hier als u tekst wilt invoeren.

6. Did you receive the accelerometer?

- ☐ Yes
- ☐ No
- ☐ Other, namely: Klik hier als u tekst wilt invoeren.

7. How often did you wear the accelerometer?

- ☐ Every day
- ☐ At least twice a week
- ☐ At least once a week
- ☐ At least once a month
- ☐ Other, namely: Klik hier als u tekst wilt invoeren.

8. Did you have contact with an occupational assessor?

- ☐ Yes. I have had contact with an occupational assessor before and after surgery.
- ☐ Yes. I have had contact with an occupational assessor before surgery.
- ☐ Yes. I have had contact with an occupational assessor after surgery.
- ☐ No, I did not have any contact with an occupational assessor

9. Did you have contact with your employer regarding surgery?

- ☐ Yes, before and after surgery
- ☐ Yes, before surgery
- ☐ Yes, after surgery
- ☐ No

10. Did a consultation took place five weeks after surgery with you, the occupational assessor, occupational phySiCian and the physiotherapist?

- ☐ Yes
- ☐ No
- ☐ Other, namely: Klik hier als u tekst wilt invoeren.

11. What did you experience as good about this trajectory, and what could be better?

- ☐ Klik hier als u tekst wilt invoeren.



CHAPTER

4

Protocol for a multicenter study on effectiveness and economics of the Back At Work After Surgery (BAAS): a clinical pathway for knee arthroplasty

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Abstract

Background - Optimizing return to work (RTW) after knee arthroplasty (KA) is becoming increasingly important due to a growing incidence of KA and poor RTW outcomes after KA. We developed the Back At work After Surgery (BAAS) clinical pathway for optimized RTW after KA. Since the effectiveness and cost analysis of the BAAS clinical pathway are still unknown, an analysis on effectiveness and costs of BAAS is imperative.

Method - This protocol paper has been written in line with the standards of Standard Protocol Items: Recommendations for Interventional Trials. To assess the effectiveness and cost-effectiveness for RTW, we will perform a multicenter prospective cohort study with patients who decided to receive a total KA (TKA) or a unicompartmental KA (UKA). To evaluate the effectiveness of BAAS regarding RTW, a comparison to usual care will be made using individual patient data on RTW from prospectively performed cohort studies in the Netherlands.

Discussion - One of the strengths of this study is that the feasibility of the BAAS clinical pathway was tested at firsthand. Also, we will use validated questionnaires and functional tests to assess the patient's recovery using robust outcomes. Moreover, the intervention was performed in two hospitals serving the targeted patient group and to reduce selection bias and improve generalizability. The limitations of this study protocol are that the lead author has an active role as a medical case manager (MCM) in one of the hospitals. Additionally, we will use the data from other prospective Dutch cohort studies to compare our findings regarding RTW to usual care. Since we will not perform an RCT, we will use propensity analysis to reduce the bias due to possible differences between these cohorts.

Trial registration: This study was retrospectively registered at ClinicalTrials.gov, NCT05690347; first registration 19 January 2023.

Background

Optimizing return to work (RTW) after knee arthroplasty (KA) is becoming increasingly important due to the growing incidence of KA and poor RTW outcomes after arthroplasty. The incidence of KA is predicted to rise substantially in the coming decades in countries with established market economies.¹⁻⁴ The largest increase is expected among patients of working age.⁵ For instance, in 2030 the United States of America will be the first country where the majority of patients getting KA are of working age, followed by Great Britain in 2035.^{3,4} Although outcomes regarding pain relief and improved knee function after KA are satisfactory, RTW among patients getting KA is relatively low. Prospectively reported non-RTW rates are 33% within six months after KA and 13% within 12 months in the Netherlands.⁶ Also, the economic burden of knee osteoarthritis in the Netherlands is high. The average annual cost for the Dutch workforce due to sick leave for knee osteoarthritis was 26.9 million euros between 2015 and 2017.⁷ Considering the increase in the demand from patients seeking KA, the low RTW outcomes after KA, and a high economic burden, care optimization for patients getting KA with a focus on RTW is essential.

A closer collaboration between professionals in medical care (e.g. orthopedic surgeon, physical therapist) and occupational care (e.g. occupational physician) for working-age patients with KA might improve their RTW probabilities after surgery.⁸ From the patient perspective, an individual tailored, integrated (health care and work-directed), comprehensive (from pre-operative to RTW) clinical pathway should preferably include integrated and coordinated care from four domains: (i) rehabilitation (e.g. physical therapy); (ii) patient support (e.g. setting proper goals); (iii) occupational support (e.g. proper build-up modified work); and (iv) medical support (e.g. more personal guidance from the hospital).^{9,10} Unfortunately, proven effective work-directed care is currently not available for patients receiving KA.^{11,12}

Recently, an integrated clinical pathway called Back At work After Surgery (BAAS) was started, aiming to improve RTW after KA. BAAS was proven feasible in 2021 in practice (Additional file 1: Appendix I).¹³ The development of this care pathway was based on two pillars.¹⁴ The first pillar was a timely combination of medical and occupational care, and the second pillar was enhancing patient participation during the clinical pathway. In this way, interdisciplinary communication was improved by making RTW an explicit outcome of the rehabilitation, which might accelerate both rehabilitation and RTW. The next step is to analyze the effectiveness and costs of the BAAS clinical pathway to RTW.

To the best of our knowledge, this is the first study on work-directed and patient-centered care after KA systematically involving health care experts other than an orthopedic surgeon and a physical therapist. Timely involvement of occupational care experts seems to be an important evidence-based prerequisite to ensure that the BAAS clinical pathway can be more effective on RTW after KA than usual care.^{6,13,15} However, since the true effectiveness and costs or benefits of the BAAS clinical pathway are still unknown, analysis on effectiveness and economic evaluation of BAAS is expedient. Our hypotheses are that an integrated clinical pathway with a focus on RTW after KA is more effective on RTW than usual care, and has a positive economic evaluation.

This multicenter study has two aims. Firstly, to assess the effectiveness of the BAAS clinical pathway for RTW compared to usual care. Secondly, to evaluate the economics of the BAAS clinical pathway compared to usual care. This paper describes the study protocol for the multicenter study.

Methods

Study design

This protocol paper has been written in line with the standards of Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT).¹⁶ We will perform a multicenter prospective cohort study with patients who have decided to be given a total KA (TKA) or a unicompartamental KA (UKA). To establish generalizability, the BAAS pathway will be performed in two high-volume KA hospitals in the Netherlands serving a representative population of working patients receiving KA. For the effectiveness of BAAS regarding RTW, the results of the study will be matched in pairs and compared to individual patient data on RTW by matched pairs from prospectively performed cohort studies in the Netherlands on care as usual, namely the Expect to Work cohort and the ACTIVE trial.^{17,18} For the economic evaluation, a comparison will be made with individual patient-level data using the care-as-usual group of the ACTIVE trial in the Netherlands.¹⁷ The study has been approved by the Medical Ethical Committee of the Amsterdam UMC, location AMC (reference ID: W21_454 # 21.504) and the Medical Ethical Committees of the local hospitals Nij Smellinghe (NS, reference ID: 19,888) and Elizabeth Tweesteden Ziekenhuis (ETZ, reference ID: L1429.2021).

Study setting

This study will take place in two hospitals in the Netherlands. The first is Nij Smellinghe (NS) hospital located in Drachten, in the northern part of the

Netherlands. NS has approximately 320 clinical beds and three orthopedic surgeons who perform approximately 350 KAs a year. The second is the Elizabeth Tweesteden Ziekenhuis (ETZ), a larger regional hospital located in Tilburg, in the southern part of the Netherlands. ETZ has 940 beds and 6 orthopedic surgeons who perform approximately 700 KAs a year.

Participants

Sample size

A minimal required sample size was calculated using R (version 3.6.3) with a power of 0.8 and a significance level of 0.05. The effect size was calculated with a mean difference of two weeks in comparison to a Dutch study on RTW after KA.¹⁵ With a calculated minimal required sample size of 125 and an expected loss to follow-up of 20%, we intend to include 150 patients (75 in NS and 75 in ETZ).

Recruitment

Inclusion criteria for patients are: (ii) being scheduled for primary or revision UKA or TKA by an orthopedic surgeon between January 2022 and July 2023; (ii) having paid work for at least eight hours a week before surgery; (iii) being between 18 and 65 years of age and (iv) having the intention to fully RTW after surgery. Criteria to exclude patients are: (i) receiving more than one medical event within one year that affects work ability after KA; (ii) having a KA for any other reason than knee osteoarthritis; and (iii) having major disabling mental disorders. Patients who do not speak or read Dutch are given the opportunity to fill in the questionnaires with the aid of a translator and to have an interpreter present during the consultations. Patients who are eligible to participate are informed about the study by telephone by the medical case manager (MCM; physical therapist working in the hospital). During an intake consultation with an MCM, the patient information letter, informed consent, and an infographic of the BAAS clinical pathway (Additional file 1: Appendix I) are handed out to the patient. Patients' questions regarding participation are answered. Patients are given one week to decide whether or not they wish to participate. Patients who opted for the possibility to participate receive a telephone call after one week so that they can ask any additional questions about the study and they will be asked if they want to participate. Participants willing to participate sign the informed consent.

Patient timeline

Since the analysis on effectiveness and economic evaluation will be conducted on the same cohort, the participant timeline will be identical (Fig. 1 and Table 1).

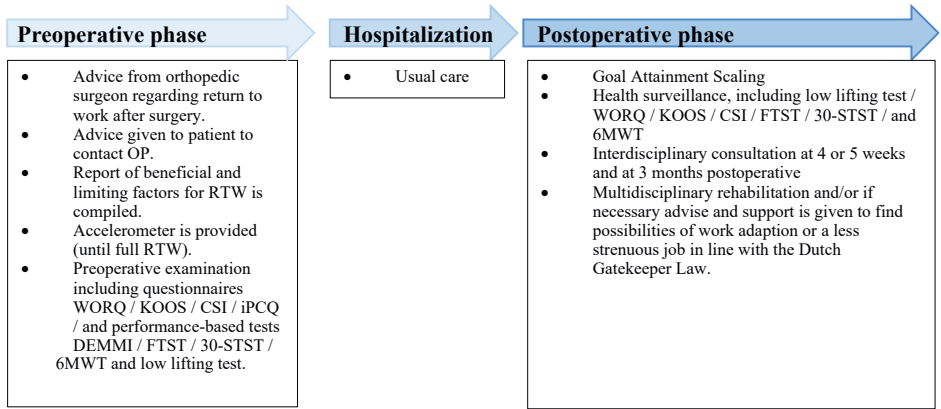


Figure 1: The BAAS clinical pathway.

Abbreviations: 6MWT = 6-minute walk test, CRT = Chair Rise Time, CSI: Central Sensitization Inventory, DEMMI = de Morton Mobility Index, FTST: Five Time Sit to Stand, iPCQ = iMTA Productivity Cost Questionnaire, KOOS = Knee Osteoarthritis Outcome Score, OP = occupational physician, RTW = return to work, WORQ = Work, Osteoarthritis and Joint-Replacement Questionnaire.

Measures

Primary outcomes

For the study on effectiveness, the primary outcomes are first day of RTW and/or first day of full RTW. First day of RTW is defined as: time in days from surgery to the first day of returning to work, regardless of the number of working hours or tasks performed. Full RTW is defined as: time in days from surgery to the first day a patient works the number of hours stated in his or her employment contract regardless of the tasks performed. For self-employed patients, full RTW is defined as: the first day of the week a patient works the number of hours equal to the number of hours he or she worked before surgery. For the first days to RTW the prospective Expect to Work study by Van Zaanen et al. will be used as usual care cohort, and for full RTW the ACTIVE trial comparison group by Straat et al. will be used.^{17,18} Test-retest reliability, minimal clinical importance difference, and minimal detectable difference of self-reported RTW are not described in the medical literature, if we are not mistaken. The effectiveness study of BAAS will be reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.¹⁹

Table 1: Measurements on different time points

TIME POINT		STUDY PERIOD						
		<i>t₀</i> <i>Preoperative ± 2-4 weeks before surgery</i>	<i>Surgery</i>	<i>t₁</i>	<i>t₂</i>	<i>t₃</i>	<i>t₄</i>	<i>t₅</i>
Primary outcomes								
First day of return to work*				X	X	X	X	X
First day of full return to work*				X	X	X	X	X
Costs					X	X	X	X
Secondary Outcomes								
Work								
Number of sick leave periods					X	X	X	X
Patient reported outcomes								
WORQ*		X		X	X	X	X	X
CSI*		X		X	X	X	X	X
KOOS*		X		X	X	X	X	X
Work Ability Score		X			X	X	X	X
Performance-based functioning								
DEMMI*		X		X	X	X	X	X
6 MWT*		X		X	X	X	X	X
30-STST*		X		X	X	X	X	X
FTST *		X		X	X	X	X	X
Floor-to-waist lifting test*		X			X	X	X	X
Patient characteristics		X						
Process								
Compiling report of beneficial and limiting factors for return to work		X						
Interdisciplinary consultation				X				
Wearing accelerometer*								

T_0 = baseline; T_1 = 6 weeks after surgery; T_2 = 3 months after surgery; T_3 = 6 months after surgery; T_4 = 9 months after surgery; T_5 = 12 months after surgery.

Abbreviations: CSI = central sensitization inventory, DEMMI = de Morton mobility index, FTST = five time sit to stand test, iPCQ = , KOOS = knee osteoarthritis outcome score, WORQ = Work, Osteoarthritis and joint-replacement questionnaire, 6 MWT = 6-minute walk test, 30-STST = 30 seconds sit to stand test.

* = follow-up measurements stop after full return to work.

For the economic evaluation, the primary outcomes are the total costs of the intervention, and the societal and health care cost obtained by a cost-questionnaire at 3, 6, 9 and 12 months according to the guidelines of the Dutch Health Care Institute (Zorginstituut Nederland), in line with the study performed by Straat et al.^{17,20} The economic evaluation will be reported according to the

Consolidated Health Economic Reporting Standards 2022 (CHEERS 2022) and we will use the human-capital method.²¹

Costs of the BAAS care pathway intervention include: (i) cost of case managers; (ii) cost of compiling the report by the OCM; (iii) cost of professionals present at the digital interdisciplinary consultation and (iv) cost of the use of the accelerometer program. These costs will be estimated using the micro-costing approach. In other words, the cost estimation will be based on actual resources depleted, which will be assessed using prospective data collection, and will be valued in accordance with the Dutch guidelines for conducting economic evaluations in health care.²⁰ Societal cost includes occupational health care services, informal care, unpaid productivity loss, absenteeism, presenteeism and other health care services. Absenteeism (e.g. total number of sick leave days, measured prospectively by the MCM) and presenteeism (e.g. lower productivity as compared to normal while at work) will be valued using sex-specific price weights.²⁰ Unpaid productivity losses (e.g. voluntary work) and informal care are measured by asking the number of hours per week patients were unable to perform unpaid activities in the cost-questionnaire. Unpaid productivity losses and informal care will be valued using a recommended Dutch shadow price.²⁰ Using consumer price indices, all costs will be converted to the same reference year by using the human-capital method.

For health care costs, all costs according to the formal Dutch health care sector will be obtained, including cost of primary care (e.g. family physician or primary care physical therapist), secondary care (e.g. hospital stays and visits), tertiary care (vocational rehabilitation) and medication. If available, these will be valued using Dutch standard costs.²⁰ If unavailable, prices of professional health care organizations will be used. Medication use will be valued using prices derived from <http://www.medicijnkosten.nl>. All costs will be summed and divided by the number of participants, separate for both groups. This will lead to average (95% CI) total costs per participant.

Secondary measures

The Work, Osteoarthritis and Joint-Replacement Questionnaire (WORQ) is a questionnaire containing thirteen 0–4-scale questions regarding perceived difficulty with performing work-related knee straining activities, calculated to a 0–100 total score, in which a higher score represents less difficulties performing the activity.²² The WORQ is a reliable, valid, and responsive questionnaire that can be used to evaluate the impact of knee complaints following KA on patients' ability to work with an inter rater correlation (ICC) of 0.97.²²

The Knee Injury and Osteoarthritis Outcome Score (KOOS) is a questionnaire containing thirty-seven 0–4 ordered category questions regarding KA-related symptoms, pain, activities, sport participation, and quality of life domains, normalized into a 0–100 total score on every domain, in which a higher score represents less restriction on the given domain.^{23,24} The KOOS demonstrates adequate content validity, internal consistency, test–retest reliability, and construct validity with an ICC of 0.85–0.90.²⁵

The Central Sensitization Inventory (CSI) is a questionnaire containing twenty-five 0–4-scale questions regarding pain sensitization-related symptoms in which a higher score represents a higher change on pain sensitization-related symptoms.²⁶ The Dutch translation of the CSI has four distinguishable domains, has good internal consistency for the total score and three out of four domains, good discriminative power, and excellent test–retest reliability.²⁶

The Work Ability Score (WAS) consists of the worker's self-reported current work ability compared to the lifetime best. The score ranges from 0 to 10 and a lower score represents a lower ability to work.²⁷ The WAS is more user-friendly than the Work Ability Index and has a good and comparable reliability.²⁸

The iMTA Productivity Cost Questionnaire (iPCQ) is a questionnaire containing cost-related questions regarding health and work.^{29,30} Test–retest reliability, minimal clinical importance difference, and minimal detectable difference of the iPCQ are unknown.

The de Morton Mobility Index (DEMMI) is a 15-item unidimensional mobility instrument that measures static and dynamic balance. The 15 items are recalculated to a 0–100 points score, in which a higher score represents better mobility.³¹ The DEMMI has a good validity, a Minimal Detectable Change (90; MDC), and minimal clinical important difference (MCID) of respectively 9 and 10 points.³¹

The 6MWT is a walk test in which the maximum walking distance is measured during a period of six minutes.³² The 6MWT has an MCID of 74.3 m.³³

The 30-STST is an instrument to assess the functional status of patients. A patient is asked to perform as many sit and stand repetitions within 30 s without using their hands. The 30-STST is a valid and reliable instrument and has an MCID of 1.13.³⁴

The FTST is a similar test to the 30-STST and measures the time it takes for a patient to perform 5 sit and stand repetitions without using their hands. Because of their similarity, the 30-STST and FTST can be performed simultaneously. The FTST is a valid and reliable instrument and has an MCID of 2.3 s.³⁵

The floor-to-waist lifting test is a reliable and valid performance-based test to assess a patient's functional capacity.^{36,37} Reference values to assess whether a patient is restricted regarding functional capacity to RTW are between 16 and 24, dependent on the physical nature of the job.³⁸

Demographics

We will collect age, sex, length, weight, type of surgery (UKA/TKA), side of surgery (left/right), length of stay, working hours per week, working days per week, physical nature of the job, preoperative sick-leave days, breadwinner, being self-employed, comorbidities, and complications after surgery.

Study intervention

The following BAAS work-directed care is offered to the patient, which was proven feasible (Additional file 1: Appendix I).¹³ The orthopedic surgeon provides information before surgery about returning to work after surgery in terms of expected time to RTW and the known prognostic factors like female gender, affirmative patient-reported work-relatedness of knee symptoms, high physical work demands, high Body Mass Index (BMI), and prolonged preoperative sick absence from work.^{39,40} Next, the orthopedic surgeon refers the patient to the MCM for a preoperative examination. During this preoperative examination, the patient fills out several questionnaires (WORQ, KOOS, CSI, WAS and iPCQ; Table 1) so the MCM gains insight in the preoperative status of the patient (Fig. 1). Then, the patient is subjected to performance-based physical tests to evaluate the functional capacity, namely a floor-to-waist lifting test and functionality tests, including the DEMMI, FTST, 30-STST, and 6MWT. During this preoperative examination, the patient is given information about the perioperative care and has the opportunity to ask questions about the recovery trajectory. The findings of the preoperative examination are used as baseline measurements for setting goals in the postoperative rehabilitation and as reference values for postoperative recovery. Next, the patient receives an accelerometer (PAM 2.0), including the option of feedback from the software application Atris (Peercode B.V.) during the preoperative examination. The movement data is accessible for the patient, the primary care physical therapist, and the MCM. A week later, the MCM calls the patient to discuss the current physical activity assessed by the accelerometer and give advice on the preferred physical preoperative preparation. For example,

patients are advised to train functional movements required after surgery, such as walking with a walking aid, or are advised to maintain or increase the current physical fitness level by adhering to the WHO's latest physical activity guideline.⁴¹ The MCM then contacts the occupational physician to inform him or her about the participation of the patient in this clinical pathway. The patient is advised to consult the occupational physician before surgery. Then, the patient is referred to the occupational case manager (OCM; occupational assessor) by the MCM, to compile a report of beneficial and limiting factors regarding RTW after KA.

During the hospitalization, the patient receives perioperative care as usual according to the KA fast track principles in both hospitals.⁴² At NS hospital, patients who have decided to have KA receive an Oxford uncemented Partial Knee (Zimmer Biomet), NexGen LPS-Flex or CR Total KA (Zimmer Biomet) or Medial Rotation Knee total knee replacement (BdH Medical BV) or SAIPH Knee System (BdH Medical BV). At ETZ hospital, patients who have decided to have KA receive a SIGMA Total Knee System (Johnson and Johnson) or an Oxford Partial Knee (Zimmer Biomet).

In both hospitals, patients will receive physical therapy according to usual care while being hospitalized for two or three times a day, with the goal of gaining independence in activities of daily living such as walking, transfers in and out of bed or chair, and walking up and down stairs if necessary.⁴³ Also, the orthopedic surgeon and physical therapist motivate the patient to train range of motion of the knee to at least full extension (0 degrees) and 90 degrees of flexion. After hospitalization, the patient receives physical therapy from a primary physical therapy setting according to the patient's preferences and taking into account the Royal Dutch Society for Physiotherapy (KNGF) guidelines for knee osteoarthritis.⁴⁴ The physical therapist is informed that the patient is participating in BAAS care pathway, and informed about the content of this pathway through an information letter. A work-related therapy goal is set up from the start of the therapy and monitored every six weeks throughout the whole clinical care pathway using Goal Attainment Scaling (GAS, Fig. 1). Progress in recovery is evaluated through questionnaires (WORQ, KOOS, and CSI), functional capacity test (floor-to-waist lifting test), functional tests (DEMMI, FTST, and 6MWT) and the physical activity level measured by the accelerometer (Table 1). The questionnaires and functional capacity evaluations tests are repeated at 6 weeks and every 3 months after surgery (Fig. 1), with the exception of the floor-to-waist lifting test at six weeks after surgery due to patient safety reasons. Data from the accelerometer is evaluated by the MCM on a weekly basis. Stop criteria for the BAAS clinical pathway are full RTW or, if RTW was not achieved after one year.

An interdisciplinary consultation is held the fourth or fifth week after surgery. The patient, the primary care physical therapist, the MCM, OCM, and occupational physician are invited to participate (Fig. 1). During this consultation, the progress, the attainment of the GAS goal, and RTW plan according to the Dutch Gatekeeper Improvement Act are discussed. If the patient has a job which he or she probably cannot return to, for example because of high knee demands due to prolonged kneeling and squatting, the possibility of work adaptations or even the topic of finding a less physically strenuous job are discussed (Fig. 1). The interdisciplinary consultation is continued if required, for instance based on unfavorable recovery data. If, after three months a delayed recovery is seen based on the patient's experience and expert opinions of the MCM, OCM, and occupational physician, and supported by questionnaires, functional capacity evaluations and accelerometer data, the patient is referred to a multidisciplinary rehabilitation assessment (Fig. 1). Here, the patient is examined by a rehabilitation physician, occupational medicine specialist, physical therapist, and psychologist to assess barriers for delayed recovery and RTW, and whether the patient is eligible for an interdisciplinary vocational rehabilitation program. If so, the patient receives this interdisciplinary rehabilitation program.⁴⁵

The MCM from NS hospital, who is experienced in fulfilling the task of MCM through the previously performed feasibility study, will train two physical therapists working in ETZ. These physical therapists perform the tasks of an MCM in their hospital. Also, the MCMs of ETZ will be trained to perform all functional tests. Every two weeks a digital consultation will be held between all MCMs to discuss progress of the study and any questions that have arisen during the entire study period.

Data collection

For the effectiveness study, both date of surgery and RTW data are collected by the MCM. In addition to the RTW data, the preoperative data and health surveillance data (Fig. 1) are collected in the same file by the same MCM. Data management For this study, data will be coded and collected in a password-protected Microsoft Excel file. A separate Excel file will refer to the coded data of individual patients that is only accessible by the MCM.

Statistical methods

Effectiveness

The effect of the BAAS care pathway on time to RTW will be statistically tested using survival analysis and gamma regression analysis including bootstrapping using R (version 4.1.0). Missing data will be handled by multivariate imputation

using the aforementioned prognostic factors if possible⁴⁸. For the repeated measurements on the time to RTW and/or full RTW, a mixed model will be used to test and estimate the size of the BAAS effect controlling for the following potential prognostic factors of delayed RTW, namely UKA vs TKA, primary vs revision KA, gender, BMI, physical nature of the job, preoperative sick leave, and patient-reported work-relatedness of knee symptoms. Hazard ratios including 95% confidence intervals will be calculated for the intervention group and tested against both control groups. In the absence of an empirically derived MCID, a difference of two weeks will be considered clinically relevant for first day of RTW and one week for full RTW. For interpreting the magnitude of the standard mean difference (SMD), three groups are defined: (i) small (SMD = 0 – 0.2); (ii) medium (SMD = 0.2 – 0.5) and (iii) large (SMD = 0.5–1.0).⁴⁶ Sensitivity analyses on RTW will be performed for the two hospitals. Analyses will be conducted using both univariate and multivariate analyses to assess the effect size of the BAAS care pathway with and without controlling for variables. Lastly, because this control group is not from the same cohort as the intervention group, we will use propensity analysis (matched pairs) to correct for other confounding factors.⁴⁷ Potential prognostic factors for delayed RTW like UKA vs TKA gender, BMI, physical nature of the job, preoperative sick leave and patient-reported work-relatedness of knee symptoms will be used for patient matching. Secondary outcomes will be plotted in time and will be tested on differences between the usual care cohorts and the intervention cohort.

Economic evaluation

For the economic evaluation, missing data will be imputed using multivariate imputation using the aforementioned prognostic factors if possible.⁴⁸ An Ordinary Least Squares regression model with bootstrapping will be used to investigate the differences between the BAAS cohort and the usual care cohort of the ACTIVE trial. Lastly, because this control group is not from the same cohort as the intervention group, we will use propensity analysis to correct for the two different cohorts (intervention and control).⁴⁷ Potential prognostic factors for delayed RTW like UKA vs TKA gender, BMI, physical nature of the job, preoperative sick leave, and patient-reported work-relatedness of knee symptoms will be used for patient matching. Results will be plotted for interpretation. The difference in costs and benefits are clinically relevant when the intervention has more financial benefit in comparison with usual care.

Discussion

This study describes the protocol to evaluate the effectiveness of the BAAS care pathway for RTW as well as its costs and benefits. To the best of our knowledge, this is the first work-directed and patient-centered care after KA systematically involving health care experts other than an orthopedic surgeon and a physical therapist.

To the best of our knowledge, there is no previous study concerning minimal clinical differences in return to work after surgery. Therefore, we held a consensus meeting with authors DS, GS, TB, PK and MR in which we concluded that a minimal clinical difference of two weeks on start to return to work and one week for full return to work is relevant.

Until now, no core outcome set exists for work participation including RTW to be used in intervention studies.^{49,50} Previous studies on RTW among patients with knee arthroplasty defined RTW in different ways. For example, Hylkema et al. measured the proportion of full RTW within 3, 6 or 12 months by asking the patient via a questionnaire whether they partially or fully returned to work, or not at all.⁶ Tilbury et al. measured RTW by asking patients through a follow-up questionnaire what the duration from operation until the first day of RTW was.¹⁵ Systematic reviews on RTW among patients with knee arthroplasty concluded that pooling data on RTW results in heterogeneity due to these varying RTW outcomes. To obtain a valid comparison, we used the same RTW definitions as those used in the prospective studies of Straat et al. and Zaanen et al.^{17,18} While this RTW definition is needed to compare the results with the prospective studies, it also means that comparisons with other studies (vice versa) should be performed carefully.

The strengths of this protocol are that the BAAS clinical pathway was already proven feasible.¹³ This way, not only did we learn that BAAS was feasible to implement, but we also learned important lessons to optimize the BAAS clinical pathway before evaluating its effectiveness, costs, and benefits. Also, the feasibility showed us promising results on the first day of RTW and full RTW in comparison to other Dutch prospective studies on RTW after KA. For example, patients started on average after 6.4 [6–8.1] weeks, in comparison to 12.9 weeks in the study of Tilbury et al.¹⁵ Patients fully returned to work on average after 12.4 [9.4–14.4] weeks, in comparison to the study of Hylkema et al., where 49% of the patients took more than six months to full RTW.⁸ Of course, the present study should show whether these RTW data are reliable and valid. Also, we will

use reliable and valid questionnaires and functional tests to assess the patient's recovery. In addition, patients who experience widespread sensitization after KA are identified early and can be referred for multidisciplinary vocational rehabilitation.^{45,51} Also, by setting personal goals regarding work-related knee-straining activities using Goal Attainment Scaling, all the involved professionals have a focus towards work participation.⁵² This probably supports both patient and professional in a timely and better collaboration between professionals within the medical and occupational trajectory. By focusing on these work-related activity goals, we aim to create more awareness in the multidisciplinary team about the values and needs of patients regarding their disability and what he or she is intended to achieve in work.

In transition processes, in which care as usual is replaced by a new care pathway, the essential role of the patients and health care professionals is often overlooked. Therefore, in our study the professionals involved in the care transitions in the two hospitals will collect and scrutinize the data together and, based on the results, determine what kind of action should be performed to enhance RTW in close contact with the patient. One of the consequences of this iterative cycle will be that all professionals as well as the patients involved become partners in achieving an optimal RTW. This way, the embedded scientist who, in daily practice, collects, creates, and reviews knowledge, and investigates the effectiveness of this newly implemented care pathway is an essential actor in creating and implementing future RTW pathways for other groups of working age patients.

Lastly, by using the data from two Dutch cohorts on RTW with similar inclusion criteria, our study is designed to be more cost-effective than a randomized controlled trial.

The limitations of this study protocol are that the lead author has an active role as an MCM in this study. This is why we included patients from a second hospital (ETZ). Also, we will not perform an RCT. We will use the data from two other prospective cohort studies with similar inclusion criteria to compare our findings to usual care. The care for knee arthroplasty is, fortunately, largely standardized in the Netherlands.^{44,53} Also, we will use propensity analysis to reduce the bias due to possible differences between our cohorts and the two comparison cohorts.^{17,18}

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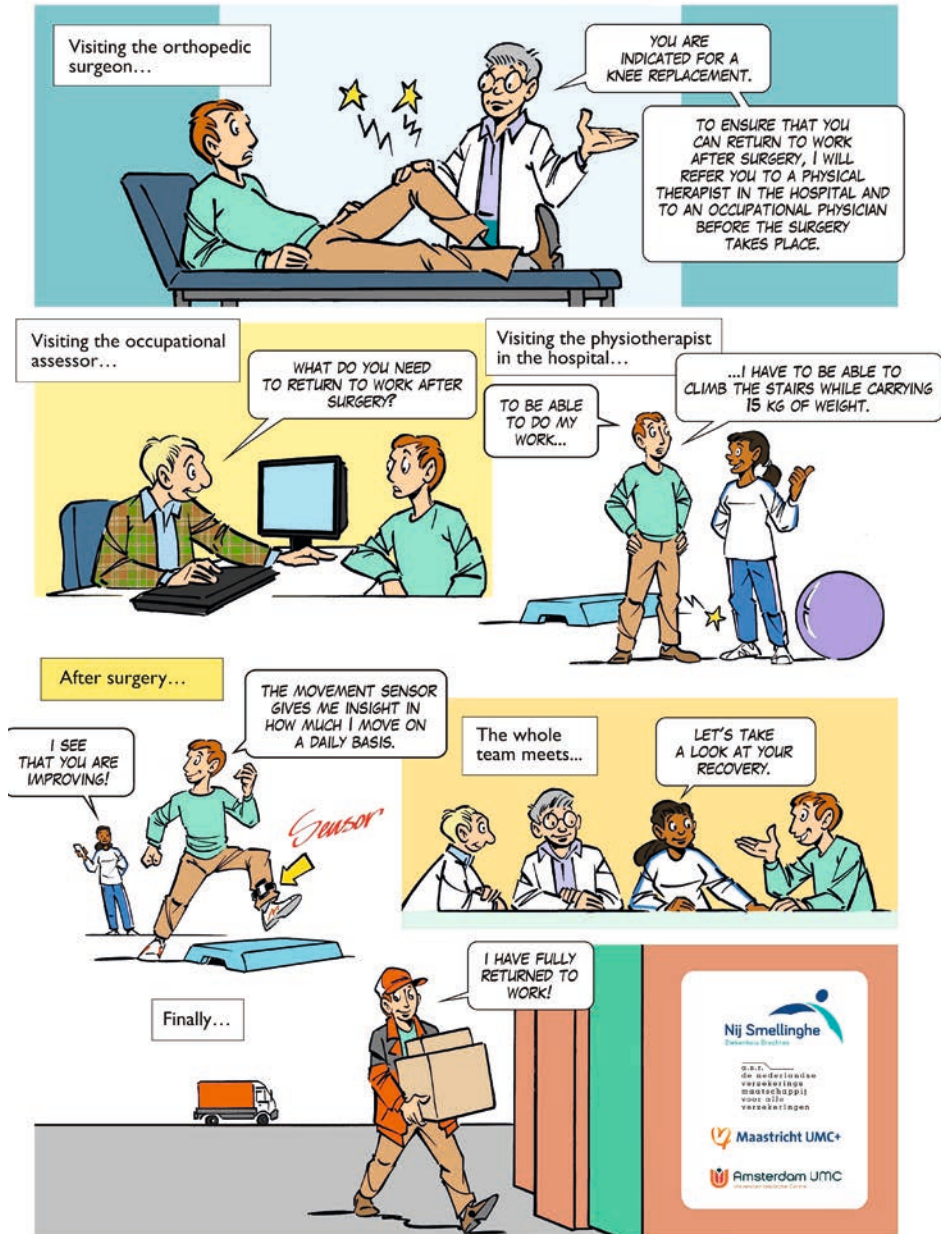
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Appendix I - Comic strip of BAAS clinical pathway

Back At work After Surgery (BAAS)





CHAPTER

5

The Effectiveness of the Back At work After Surgery (BAAS) Work-Integrated Care Pathway on Return to Work for Patients Receiving Knee Arthroplasty: A Study of Three Comparative Cohorts in the Netherlands.

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Abstract

Purpose: Considering the increase in the demand from working-age patients seeking knee arthroplasty (KA) and the low return-to-work (RTW) rates, optimization of care for patients getting KA with a focus on RTW is essential. We evaluated a work-integrated care pathway—Back At work After Surgery (BAAS)—aimed at improving RTW compared with care-as-usual in the Netherlands.

Methods: In this multicenter study of three comparative cohorts, working patients who had primary KA were included. Patients in two Dutch hospitals (BAAS cohort) received integrated medical and occupational care, including structured pre- and postoperative consultations, goal setting, activity tracking and interdisciplinary team meetings with both medical and occupational health professionals. Two independent control cohorts with comparable patient inclusion criteria (Expect TO work and ACTIVE) from 15 hospitals/clinics received care-as-usual. The primary outcomes were the time to first day of RTW and time to full RTW within 12 months. Inverse Probability of Treatment Weighting was used with known prognostic factors as covariates to account for possible differences in baseline characteristics.

Results: A total of 457 patients were included (BAAS n=145; Expect TO work n=179; ACTIVE n=133). The median time to first day of RTW was 16-25 days shorter in the BAAS cohort (27 days) compared to Expect TO work (52 days; hazard ratio [HR] 2.7; 95% confidence interval [CI]:2.1-3.4) and ACTIVE cohort (43 days; HR:1.95; CI:1.5-2.6). At three months, 90% of BAAS patients had started RTW versus 63% and 77% in the control cohorts. BAAS patients also achieved full RTW earlier, with a median time reduced by 27 days compared to the ACTIVE cohort (HR:1.4; CI:1.1-1.8). The odds of full RTW at 12 months were higher in the BAAS cohort compared to Expect TO work, namely odds ratio (OR) 5.0 (CI:1.3-18.5) and ACTIVE OR 9.3 (CI:2.5-34.8).

Conclusions: The BAAS work-integrated care pathway was more effective than care-as-usual in improving RTW after KA in the Netherlands.

Trial registration: This study was retrospectively registered at [clinicaltrials.gov](https://clinicaltrials.gov/ct2/show/NCT05690347) (<https://clinicaltrials.gov/ct2/show/NCT05690347> , date of first registration: 19-01-2023).

Key words: Orthopedic Procedures, Rehabilitation, Occupational Medicine, Knee, Arthrosis.

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Introduction

Work participation is a strong predictor of health, and should therefore be an important outcome measure in healthcare. Unfortunately, work participation is often overlooked and taken for granted in practice and science.¹⁻⁷ In addition, working individuals contribute more effectively to society.⁸⁻¹¹ The importance of maintaining employment, therefore, contributes to valued individual and societal outcomes.

Care-as-usual often falls short in assisting individuals to stay at work or return to work (RTW) during or after an illness or medical condition.¹²⁻¹⁴ This shortcoming requires that healthcare professionals should consider additional steps to secure work participation into their treatment.¹⁵ Such additional steps for chronic low back pain have demonstrated that patients improved RTW with a median of 120 days (88 vs. 208).¹⁶ These additional steps can similarly be applied to common planned surgeries, like knee arthroplasty (KA). RTW after KA is a growing problem, due to the rising incidence of KA among patients of working age, and poor return to work outcomes.¹⁷⁻²² Despite the favorable outcomes of KA in terms of pain and knee function, RTW among patients is low with reported worldwide non-RTW rates of 35%.¹³ In the Netherlands, a similar non-RTW rate is seen with 31%.²³ Considering the increase in the demand from working age patients seeking KA and the low RTW rates after KA care, optimization of care for patients getting KA with a focus on RTW is essential.

To improve RTW after KA, a work-integrated care pathway named Back At work After Surgery (BAAS) was developed.²⁴ This pathway emphasizes a timely integration of medical and occupational care, enhancing patient participation throughout the perioperative clinical process with core components such as structured pre- and postoperative consultations, personalized goal setting, physical activity monitoring, and interdisciplinary meetings. BAAS' feasibility in practice was demonstrated.²⁵ However, the effectiveness of BAAS for RTW was unknown. Our hypothesis was that the BAAS work-integrated care pathway is more effective on RTW than care-as-usual.

Methods

Study design

We conducted a prospective cohort study evaluating the effectiveness of BAAS compared to two comparative cohorts studying care-as-usual as described in the Expect TO work cohort and ACTIVE trial.^{26,27} Ethical approval for the study

was granted (reference IDs: W21_454#21.504 and L1429.2021). Reporting of this study adhered to both CONSORT and STROBE (Appendix I).^{28,29}

Participants and study setting

A minimal required sample size was calculated using R (version 3.6.3) with a power of 0.8 and a significance level of 0.05. The effect size was calculated with a mean difference of two weeks in comparison to a Dutch study on RTW after KA.³⁰ With a calculated minimal required sample size of 125 and an expected loss to follow-up of 20%, we intend to include 150 patients. Inclusion and exclusion criteria were similar for all three cohorts (Appendix II). The recruitment procedure for BAAS is described in the protocol paper.²⁴ Patients were followed from recruitment before surgery until 12 months post-operatively or until full RTW was achieved. The BAAS study was performed in two hospitals in the Netherlands, Nij Smellinghe Hospital (NS) and Elizabeth Tweesteden Ziekenhuis (ETZ). These hospitals perform approximately 450 and 600 KAs annually.²⁴ The Expect TO work study was performed in seven Dutch hospitals, performing 430–770 KAs annually.²⁷ The ACTIVE trial was performed in eleven Dutch clinics and hospitals, performing 100–800 KAs annually.²⁶

Patient and public involvement

To incorporate patient and public involvement, patients who had previously received KA, employers and an insurance company were consulted in the early development and feasibility testing of the BAAS work-integrated care pathway.²⁵

Care-as-usual

In the Netherlands, patients with symptomatic knee osteoarthritis (OA) are typically first managed with conservative treatments, such as physical therapy, pain medication, and lifestyle advice. Referral to an orthopedic surgeon and subsequent consideration for total knee arthroplasty (TKA) usually occurs when conservative treatment is no longer sufficient to relieve pain or restore function. According to national guidelines, an appropriate indication for TKA requires radiographic evidence of OA (e.g. Kellgren-Lawrence grade ≥ 2), significant limitations in daily life or work participation, and shared decision-making based on realistic expectations regarding outcomes and recovery.³¹ Recovery after KA is clinically guided by a physical therapist who works in a hospital, while after discharge it is often guided by a primary care physical therapist who works accordingly to their professional guideline.³²

Parallel to the medical process, working patients in the Netherlands are legally supported by the Gatekeeper Improvement Act, which mandates early and

structured RTW guidance after sick leave. Employers and occupational physicians are required to collaborate on a reintegration plan within six weeks of sick leave. The occupational physician evaluates work capacity and facilitates graded work resumption. In more complex cases, an occupational assessor may be involved to assess job demands, possibilities for workplace adaptations, or options for job transfers, often offered one year after sick leave. However, orthopedic care including rehabilitation and occupational support are typically not well integrated, and RTW is not a standard focus within usual perioperative orthopedic care.

The BAAS intervention

The BAAS work-integrated care pathway started with the indication of KA made together by the patient orthopedic surgeon, who actively refers the patient for a preoperative consultation by a hospital-based physical therapist. In this consultation, patients received counseling to optimize their preparation for surgery. Also, the patients completed several standardized questionnaires and performed functional tests to set a baseline measurement, which were used for evaluating clinical recovery.²⁴ A work-related therapy goal was set using Goal Attainment Scaling (GAS).³³ Patients were asked to wear an accelerometer from 2-weeks preoperatively (PAM 2.0, PAM B.V., Oosterbeek, the Netherlands) to monitor physical activity with real-time feedback accessible to patients and healthcare professionals via the Atris app (Peercode, Geldermalsen, the Netherlands). An occupational assessor compiled a report of beneficial and limiting factors regarding RTW based on a preoperative workplace assessment (Appendix III).

Around the fourth or fifth week after surgery, an online team meeting was held involving the patient, primary care physical therapist, hospital-based physical therapist, occupational assessor, and occupational physician. This interdisciplinary consultation focused on evaluating the recovery progress and using this information to refine the RTW plan, if necessary. Next to this online interdisciplinary consultation, postoperative consultations by the hospital were organized at 6 weeks and every 3 months thereafter, up to 12 months or until full RTW was achieved. During these consultations, recovery was assessed by monitoring the GAS goal, and by using the same questionnaires and functional tests as those at baseline.

Postoperative care included targeted physical therapy in a primary care setting, adhering to the Royal Dutch Society for Physiotherapy guidelines for knee osteoarthritis.³² If the hospital-based physical therapist expected that a patient could not RTW within 12 months —based on patient experience,

clinical assessments, and accelerometer data—patients were referred for a multidisciplinary rehabilitation assessment in an academic hospital. This assessment could lead to participation in a vocational rehabilitation program.

Outcome measures

Primary outcomes

The primary outcomes were the first day of RTW and the first day of full RTW.³⁴ The first day of RTW was defined as the number of calendar days from surgery until the patient returned to work, regardless of the number of hours worked or type of tasks performed. Full RTW was defined as the number of calendar days from surgery until the patient resumed working the same number of hours as specified in their employment contract, regardless of the tasks performed. To the best of our knowledge, there is no previous study concerning minimal clinical differences (MCID) in return to work after surgery. Therefore, we held a consensus meeting with authors DS, GS, TB, PK and MR in which we concluded that a minimal clinical difference of two weeks on start to return to work and one week for full return to work is relevant.²⁴ RTW outcomes were self-reported in all three cohorts. Because the Expect TO work cohort measured RTW as a binary outcome (yes/no) at 3, 6, and 12 months, these data were incorporated to further refine and enhance the analysis compared to what was originally outlined in the protocol.

Secondary outcomes

The secondary outcomes were the KOOS and WORQ at baseline (preoperative), and at follow-up until full RTW was achieved.^{35,36} The KOOS is a 42-item, 5-point Likert scale questionnaire which can be calculated in five 0-100 domain scores.³⁶ The domains are: Pain, Other Symptoms, Activities of daily Living (ADL), Sports / Recreation and Quality of Life (QoL). The MCID of each domain is 12, 9, 10, 9, and 14 points, respectively.³⁷ The WORQ is a 13-item, 5-point Likert scale questionnaire that assesses the perceived difficulty of work-related activities and is calculated on a 0–100 scale. The WORQ has a MCID of 13 points.³⁵

Demographics

Data on age, sex, BMI, type of surgery and comorbidities were obtained from the electronic patient records. Working hours per week, physical demands of the job, preoperative sick-leave, being breadwinner, level of education and being self-employed were asked to the patient in the preoperative consultation.

Statistical methods

The statistical analysis tested the effectiveness of the BAAS work-integrated care pathway on RTW outcomes, compared with the comparative care-as-usual

cohorts. The statistical methods deviated from the protocol paper, due to the fact that a uni- or multivariate linear regression was, in hindsight, not the most robust statistical method to analyze a time-to-event outcome. All analyses were conducted using R (version 4.1.0).

Inverse Probability of Treatment Weighting (IPTW) to estimate time to RTW

To account for possible differences in baseline characteristics of the patients between the intervention and control cohorts, propensity scores were calculated using logistic regression. The relevant covariates for RTW were sex (female vs. male), type of surgery (UKA vs. TKA), BMI, physical demands of the job (knee-straining vs. non-knee-straining job), preoperative sick leave (yes vs. no), and the self-reported work-relatedness of the knee arthroplasty (ranging from 'totally agree' to 'totally disagree').^{38,39} If missing data were present in the covariates, Predictive Mean Matching via the mice package was used with five imputations to ensure robustness of the estimates. These propensity scores were used to derive inverse probability of treatment weights (IPTW), which adjusted for covariates in the regression models without performing direct matching. This method ensured that the weighted samples more closely resembled a randomized comparison between BAAS and the control cohorts. The effectiveness of BAAS on first day and full RTW was assessed using hazard ratios (HRs) including 95% confidence intervals (95% CIs) using Cox regression models. Difference in time to first day and full RTW was assessed by calculating the median including interquartile ranges (IQRs).

Logistic regression for proportions

Logistic regression models were used to assess the proportion of patients who succeeded in first day of RTW and full RTW at 3, 6, 9, and 12 months, with odds ratios (ORs) and IQRs calculated for the intervention versus control groups. Firth's bias-reduced logistic regression was used to mitigate bias in small sample sizes.

Secondary outcomes

For the secondary outcomes, mean changes in the five KOOS domains and the WORQ score were calculated for the three cohorts. A repeated measures ANOVA was performed with time (preoperative and three months postoperative) as the within-subject factor and cohort as the between-subject factor. If there was a main effect of cohort, post-hoc Bonferroni analysis assessed the effect of each cohort individually in comparison to BAAS.

Sensitivity Analyses

A sensitivity analysis was performed to determine whether outcomes differed between the two study hospitals (NS and ETZ). For each center, multivariate Cox proportional hazards models were fitted to estimate the effect of BAAS on both time to first day of RTW and time to full RTW. Median survival times for first day and full RTW were calculated for both the NS and ETZ hospitals, and interquartile ranges (IQR) were determined to assess the variability in median differences across centers.

Results

A total of 457 patients were included from three cohorts: BAAS (n=145), Expect TO work (n=179), and ACTIVE (n=133) (appendix IV). Missing data on the covariates—work-relatedness of knee OA (n=37), sick leave (n=36), BMI (n=6), and physical job demands (n=1)—were imputed for a total of 38 patients (8%). Two patients were excluded from the NS hospital cohort due to postponed surgery or due to termination of the work contract, respectively. From the 145 remaining patients, nine dropped out: eight patients were unwilling and one patient had additional surgery within the RTW period. Within the first year after surgery, 139 patients started RTW and 136 fully RTW. The characteristics of the cohorts did not differ significantly for sex, BMI and preoperative sick leave. Significant differences were observed for type of surgery, working in a knee straining job and level of education (Table 1).

Table 1: Patient baseline and perioperative characteristics. Data are numbers (n) and percentages (%) of patients unless stated otherwise

	BAAS (n = 145)	Expect TO work (n = 179)	ACTIVE Trial (n = 133)	p
Mean (SD) age (years)	58.4 (4.3)	57.9 (5.2)	58.7 (4.4)	0.308
Female sex	77 (53.1)	92 (51.4)	69 (51.9)	0.953
Mean (SD) BMI	29.4 (3.9)	29.8 (5.1)	29.7 (4.0)	0.701
Type of surgery (TKA)	115 (79.3)	179 (100)	88 (66.2)	<0.001
Comorbidities				0.150
0	115 (82.7)	149 (83.2)	103 (77.4)	
1	20 (14.4)	25 (14.0)	20 (15.0)	
>1	4 (2.9)	5 (2.8)	10 (7.5)	
Knee straining job (yes)	72 (50.0)	89 (49.7)	38 (28.6)	<0.001
Education				<0.001
No	4 (2.9)	4 (2.7)	0 (0.0)	
Primary	29 (20.7)	15 (10.1)	11 (8.3)	
Lower secondary	76 (54.3)	69 (46.3)	59 (44.4)	
Higher secondary	12 (8.6)	14 (9.4)	9 (6.8)	

Table 1: continued

	BAAS (n = 145)	Expect TO work (n = 179)	ACTIVE Trial (n = 133)	p
Higher vocational	18 (12.9)	36 (24.2)	48 (36.1)	
University or higher	1 (0.7)	11 (7.4)	6 (4.5)	
Breadwinner (yes)	80 (57.6)	113 (63.1)	81 (60.9)	0.600
Self-employed (yes)	27 (18.9)	24 (13.5)	25 (18.8)	0.328
Sick leave (yes)	30 (21.4)	36 (24.3)	27 (20.3)	0.700
Mean (SD) contract hours	31.3 (12.7)	31.8 (9.7)	32.4 (19.1)	0.833

Abbreviations: BAAS = Back At work After Surgery, BMI = Body Mass Index, SD = standard deviation, TKA = total knee arthroplasty.

Time to first day of RTW and full RTW

The BAAS cohort had an earlier first day of RTW compared to the care-as-usual cohorts Expect TO work (HR=2.7, 95%CI 2.1–3.4, $p<0.001$) and ACTIVE (HR=1.95, 95%CI 1.5–2.6) with a median of 27 days (IQR: 14–44) versus 52 (IQR: 21–66) and 43 (IQR: 31–78), respectively (figure 1). Therefore, the absolute median difference between BAAS and Expect TO work is 25 days, and between BAAS and ACTIVE 16 days. For full RTW, the median was 183 days (IQR: 115–>365 (within this analysis, >25% did not fully RTW, see figure 1)) for BAAS and 210 days (IQR: 124–>365) for ACTIVE, giving an absolute median difference of 27 days (HR = 1.4, 95%CI 1.1–1.8) (figure 2).

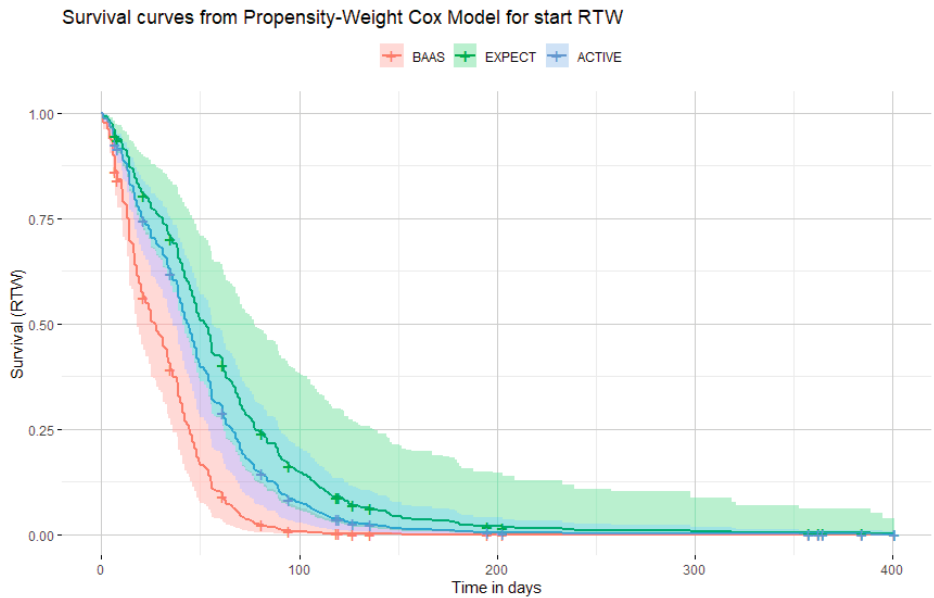


Figure 1: Survival curve of IPTW-adjusted Cox model for first day of RTW with 95% confidence interval for the cohorts BAAS, Expect TO work and ACTIVE. Abbreviations: BAAS = Back At work After Surgery.

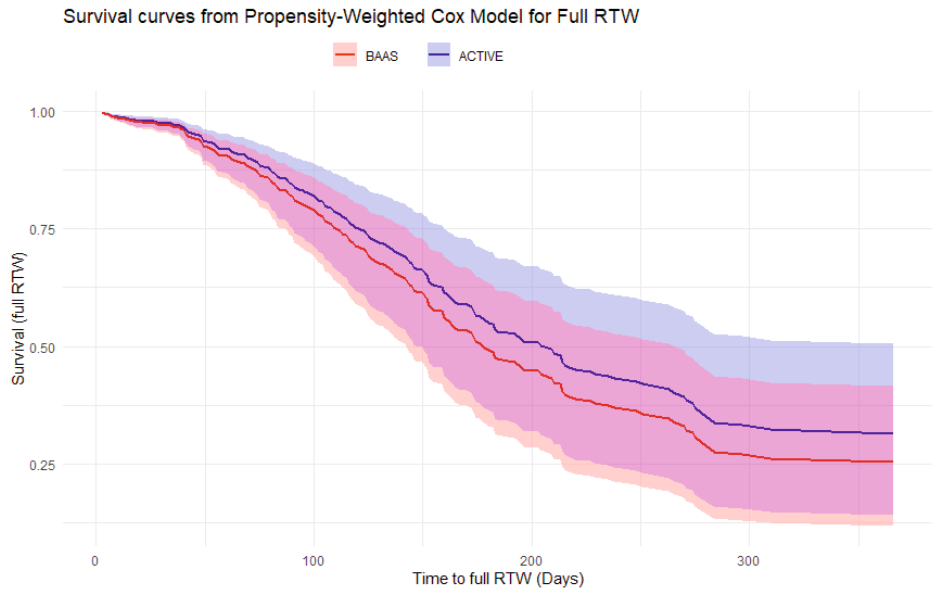


Figure 2: Survival curve of IPTW-adjusted Cox model for full RTW with 95% confidence interval for the cohorts BAAS and ACTIVE. Abbreviations: BAAS = Back At work After Surgery.

Proportions over time for first and full RTW

In the BAAS cohort, more patients (93%) started with RTW within three months, compared to Expect TO work (64%) and ACTIVE (77%). Logistic regression models with Firth’s bias-reduction method indicated significant differences in start to RTW rates across cohorts over time in favor of BAAS, with ORs ranging from 5.3 to 14.8, respectively (table 2). BAAS showed that more patients started to RTW compared to Expect TO work at 3, 6, 9 and 12 months after KA, and also at 3 and 6 months after KA compared to ACTIVE. Differences between BAAS and ACTIVE at the 9- and 12-months were non-significant.

Table 2: Odds ratios for proportions of patients starting RTW and full RTW between the cohorts BAAS, Expect TO work and ACTIVE.

Time point	Start RTW		Full RTW	
	BAAS vs Expect TO work (1/OR [95% CI])	BAAS vs ACTIVE (1/OR [95% CI])	BAAS vs Expect TO work (1/OR [95% CI])	BAAS vs ACTIVE (1/OR [95% CI])
3 months	8.0 [3.9-18.2]	7.3 [3.2-17.7]	1.4 [0.8-2.4]	0.9 [0.5-1.9]
6 months	6.8 [1.6-64.0]	7.4 [1.5-73.1]	2.9 [1.6-5.2]	2.5 [1.3-4.8]
9 months	14.8 [1.7-1951]	9.4 [0.9-1276]	Data not available	4.4 [1.7-11.6]
12 months	11.0 [1.3-1423]	5.3 [0.3-794]	5.0 [1.3-18.5]	9.3 [2.5-34.8]

Abbreviations: BAAS = Back At work After Surgery

For full RTW, in the BAAS cohort, 4 (2%) patients did not fully RTW within 12 months, compared to 22 (16%) and 17 (13%) in the Expect TO work and ACTIVE

cohort, respectively. Differences in full RTW odds at three months were non-significant. However, the BAAS cohort demonstrated significantly higher odds of patients who successfully fully RTW from six to twelve months post-surgery, with ORs ranging from 2.5 to 9.3.

Sensitivity analysis

The median time to start RTW was 43 days (IQR: 19–62) for NS hospital and 42 days (IQR: 18–60) for ETZ hospital, with a median difference of 1 day. For full RTW these data were 110 days (IQR: 75–153) for NS hospital, and 136 days for ETZ hospital (IQR: 89–192), with a median difference of 26 days.

Secondary outcomes

Given that most patients in the BAAS cohort achieved full RTW before 6 months, only the preoperative and 3 months data are presented. All KOOS domains and the WORQ outcomes showed significant improvement over this time period across all three cohorts ($p < 0.001$) (figure 3 and appendix V). Recovery for the WORQ and the following KOOS domains favored BAAS: Sports & Recreation and Quality of Life. Recovery in the following KOOS domains favored care-as-usual, exceeding the MCID, whereas BAAS did not: KOOS symptoms (only in comparison to Expect TO work) and ADL (appendix V).

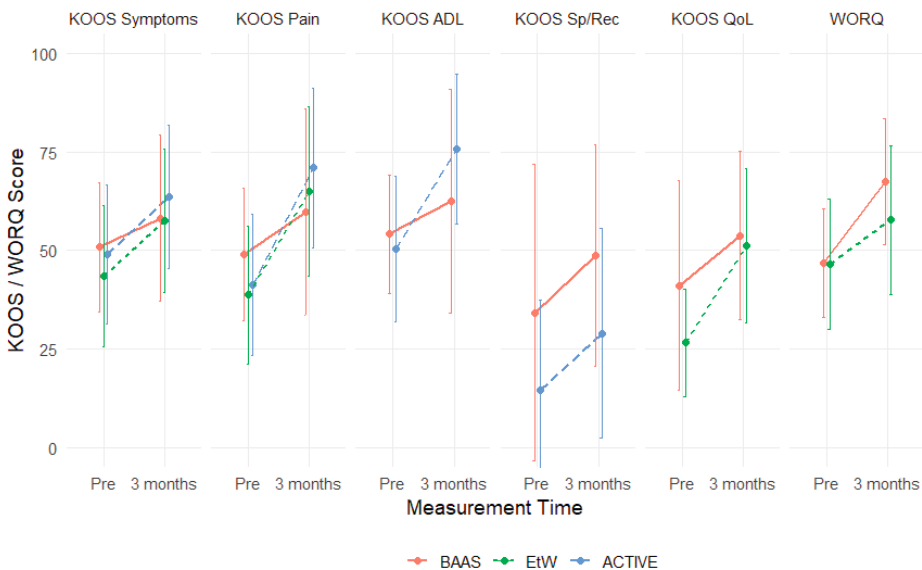


Figure 3: Mean scores (SD) for the Knee Osteoarthritis Outcome Score and the Work, Osteoarthritis and joint-Replacement Questionnaire in time (preoperative and 3 months after surgery) for the cohorts BAAS, Expect TO work and ACTIVE. Abbreviations: ADL = activities of daily living, BAAS = Back At work After Surgery, EtW = Expect TO Work, KOOS = knee osteoarthritis outcome score, QoL = quality of life, Sp/Rec = sports and recreation, WORQ = Work, Osteoarthritis and joint-Replacement Questionnaire.

Discussion

In this multicenter study of three comparative cohorts, we found that the BAAS work-integrated care pathway is more effective for RTW compared to two care-as-usual cohorts. Secondary outcomes showed clinical advantages favoring care-as-usual and participation benefits favoring BAAS, illustrating that meaningful participation (including RTW) can be achieved even when clinical outcomes are not fully optimal.⁴⁰

Our study has several strengths. First, it included a large number of patients, increasing reliability. Second, the intervention was implemented in everyday clinical practice in two hospitals, thereby increasing its generalizability. Third, the work-integrated care pathway was personalized, as each patient's recovery was monitored, goals were set using Goal Attainment Scaling, and individual work activities were discussed and taken into account. Finally, the observed time-to-RTW benefits (16–25 days earlier for start RTW and 27 days for full RTW) exceeded MCIDs.²⁴

To assess generalizability, comparison to another Dutch care-as-usual suggests the time to start RTW can be longer (84 days, SD 54) than in our two care-as-usual cohort namely 52 and 43 days.³⁰ A recent meta-analysis based on 25 studies from nine countries reported a pooled mean time to RTW of 90 days (range 35–205).¹³ BAAS with 27 days seems to outperform these care-as-usual studies. However, a reliable comparison is hard to make due to two reasons. First, there is no clear definition whether first or full RTW was measured. Second, RTW might have been calculated only for those who did RTW within the study period, instead of measuring RTW for all included patients as is done in the present study. Regarding the proportion of patients with no RTW within one year, BAAS seems to outperform the international comparison with 2% versus 35%.¹³ However, the inclusion criteria are probably not the same for instance regarding the intention to RTW after surgery.

We are aware of one other study evaluating a work-integrated care intervention after KA, namely the Finnish Coordinated Return to Work (CRTW) study.^{41,42} Patients receiving CRTW started RTW after a mean of 87 days (SD 52) compared to a median of 27 days in our BAAS-intervention cohort.⁴² Also, 13% of the patients did not RTW in the CRTW study within one year, compared to 2% in the BAAS cohort.⁴² The CRTW study, like BAAS, reported a positive result for the intervention group with a mean difference of 14.4 days (95%CI 21.3 to 7.5) compared to a median difference of 16–25 days in our study.⁴¹ Although these outcomes cannot be perfectly compared (mean vs. median), the difference is

notable. Like the systematic review with meta-analysis, the CRTW study seemed to only report time to RTW for those who did RTW and not for the patients with no RTW.^{13,41,42}

Our study contributes to the growing evidence supporting work-integrated healthcare. Thereby, not only patients benefit but also society by reducing work absenteeism. This is particularly important in KA given the current rise among patients of working age.¹⁷⁻²² BAAS prioritizes participation over solely improving physical function or reducing pain. This approach aligns with patients' experiences of recovery, which are often based on meaningful activities such as work, sports, and leisure, and poses a challenge for healthcare professionals who traditionally focus on bodily functions and structures and clinical signs.^{43,44} Furthermore, the results underscore the critical need to explore whether BAAS can similarly benefit other orthopedic procedures, like hip arthroplasty and discectomy, highlighting the profound societal value of work-integrated health care.^{13,45} Lastly, an economic evaluation showed that, in addition to being effective as demonstrated in this study, BAAS also yielded a positive return on investment of over 500% from both the societal and worker's perspective.⁴⁶

Nevertheless, four potential limitations merit consideration. First, our study design was not a randomized controlled trial (RCT). However, the two care-as-usual cohorts were comparable regarding eligibility criteria, study period, clinical setting, RTW outcomes and key covariates. Moreover, the application of IPTW adjusted for confounders for RTW, strengthening the validity of our findings. In addition, a comparison with comparable cohorts reduced both time and costs compared to an RCT, and potentially enhanced the validity of the results.^{47,48} Second, sensitivity analyses revealed that the hospital where the lead scientist directly provided part of the care (NS) achieved better full RTW outcomes compared to the other hospital (ETZ). This may be due to more extensive focus and experience of the care team. The implementation in ETZ hospital consisted of only a one-day training and a phone call every two weeks, which might have been too little. Third, RTW was measured by self-reports, which could introduce reporting bias. However, recent evidence shows that the discrepancy between registry studies and self-reported data regarding RTW are minimal, with a pooled mean difference of only 1.8 sickness absence days and for proportions a sensitivity of 0.83 and a specificity of 0.92.⁴⁹ Also, our outcomes are in line with the recently published Core Outcome Set for Work participation (COS for Work).³⁴ Lastly, Third, the BAAS intervention cohort contained proportionally more participants with a lower level of education, even after matching (table 2). Lower level of education has been linked to slower functional recovery and a longer time to RTW after

KA.⁵⁰⁻⁵³ Because education is highly correlated with physical job demands, we included only the “knee-straining job” variable in the propensity model to avoid multicollinearity, and this characteristic was balanced between groups. Residual confounding by education can therefore not be ruled out; if lower-educated workers indeed face a poorer prognosis, however, the current cost advantage observed for BAAS is likely an underestimate compared to a better education-balanced situation.

In conclusion, this multicenter study of three comparative cohorts demonstrates that the BAAS work-integrated care pathway is more effective than care-as-usual in improving return to work after KA in the Netherlands. Patients returned to work sooner and more frequently, despite comparable clinical outcomes. These findings underscore the relevance of integrating occupational support within perioperative care, especially for patients of working age. BAAS emphasizes meaningful participation, aligned with patients’ recovery goals, without compromising medical recovery. Further research is needed to evaluate its applicability in other surgical populations and healthcare contexts.

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Declaration of interest

The authors have no relevant financial or non-financial interests to disclose.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by DO Strijbos, PPFM Kuijer and G van der Sluis. The first draft of the manuscript was written by DO Strijbos and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request

Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of University of Amsterdam (28/10/2021, reference W21_454 # 21.504). Informed consent was obtained from all individual participants included in the study.

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Appendix I - STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2/3
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	3 (and protocol paper)
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	3
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	3
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4/5
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	5
		(b) Describe any methods used to examine subgroups and interactions	5
		(c) Explain how missing data were addressed	5
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	5
		(e) Describe any sensitivity analyses	5

	Item No	Recommendation	Page No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	7
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7
		(b) Report category boundaries when continuous variables were categorized	7
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9/10
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	12

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

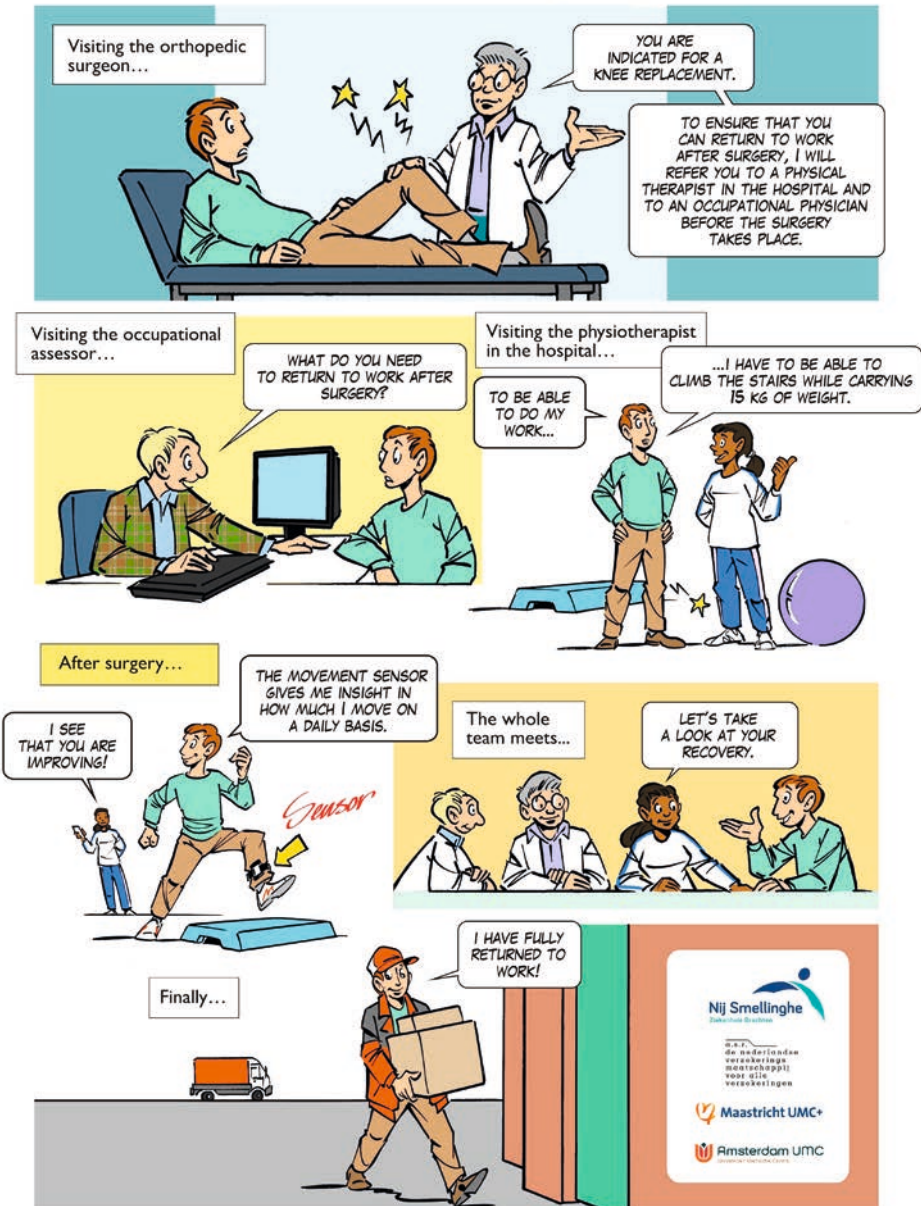
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

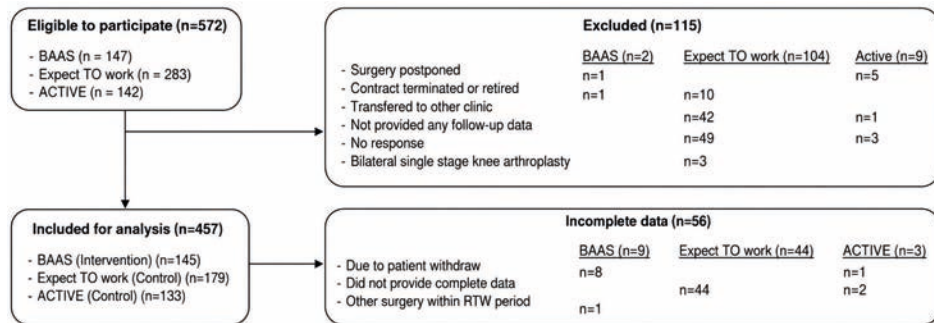
Appendix II: Inclusion and exclusion criteria, outcomes and covariates of the three cohorts: BAAS, Expect TO work and ACTIVE.

Cohort	Back At work After Surgery	Expect TO work	ACTIVE trial
Inclusion	Nov. 2021 to Apr. 2023	Jun. 2014 to Oct. 2016	Oct. 2020 to Jan. 2023
Follow-up	Twelve months or until full RTW	Twelve months	Twelve months
Inclusion criteria	1. Primary UKA or TKA 2. Age 18 – 65 3. Paid work for at least 8 hours/week 4. Intention to RTW	1. Primary TKA 2. Age 18 – 65 3. Paid work 4. Intention to RTW	1. Primary UKA or TKA 2. Age 18 – 67 3. Paid work for at least 8 hours/week 4. Intention to RTW
Exclusion criteria	1. Receiving more than one medical event affecting workability within one year 2. KA for reasons other than knee osteoarthritis 3. «Major disabling mental disorders	1. Bilateral surgery	1. Another planned joint replacement during the study period 2. Extreme comorbidity affecting recovery
Primary outcomes and covariates			
- Primary outcomes	1. Time and proportion to start RTW 2. Time and proportion to full RTW	1. Time and proportion to start RTW 2. Proportion to full RTW at 3, 6 and 12 months	1. Time and proportion to start RTW 2. Time and proportion to full RTW
- Covariates	1. Sex 2. BMI 3. Type of surgery 4. Knee straining job 5. Sick leave 6. Work-relatedness of KA	1. Sex 2. BMI 3. Type of surgery 4. Knee straining job 5. Sick leave 6. Work-relatedness of KA	1. Sex 2. BMI 3. Type of surgery 4. Knee straining job 5. Sick leave 6. Work-relatedness of KA

Appendix III – Illustration of Back At work After Surgery (BAAS)

Back At work After Surgery (BAAS)



Appendix IV - Flowchart of the cohorts BAAS, Expect TO work and ACTIVE.**Appendix V:** Mean (SD) KOOS and WORQ scores per cohort in time and the mean difference (95% CI) between cohorts.

Questionnaire (domain)	Cohort	n	Preoperative mean ± SD	Postoperative mean ± SD	Mean difference versus BAAS cohort [95% CI]
KOOS Symptoms	BAAS	124	50.8 ± 16.4	58.2 ± 21.0	
	Expect TO work	147	43.4 ± 17.9	57.5 ± 18.2	4.1 [0.1 - 8.0]
	ACTIVE	120	49.0 ± 17.6	63.6 ± 18.1	-1.8 [-6.0 - 2.4]
KOOS Pain	BAAS	124	49.0 ± 16.8	59.8 ± 26.2	
	Expect TO work	147	38.7 ± 17.5	65.0 ± 21.5	-
	ACTIVE	120	41.3 ± 17.9	70.9 ± 20.2	-
KOOS Activities of Daily Living	BAAS	124	54.1 ± 15.1	62.4 ± 28.4	
	Expect TO work	-	-	-	
	ACTIVE	120	50.4 ± 18.5	75.6 ± 19.0	4.7 [1.0 - 8.6]
KOOS Sports & recreation	BAAS	124	34.2 ± 37.6	48.8 ± 28.1	
	Expect TO work	-	-	-	
	ACTIVE	120	14.5 ± 23.0	29.0 ± 26.6	-19.7 [-25.5 - -13.9]
KOOS Quality of Life	BAAS	124	41.1 ± 26.5	53.8 ± 21.3	
	Expect TO work	147	26.6 ± 13.7	51.2 ± 19.6	-8.6 [-12.1 - -5.1]
	ACTIVE	-	-	-	
WORQ	BAAS	125	46.7 ± 13.8	67.4 ± 16.0	
	Expect TO work	147	46.6 ± 16.5	57.7 ± 18.8	-5.0 [-8.1 - -1.8]
	ACTIVE	-	-	-	

Abbreviations: BAAS = Back At work After Surgery, CI = confidence interval, KOOS = Knee Osteoarthritis Outcome Score, SD = standard deviation, WORQ = Work, Osteoarthritis and joint-Replacement Questionnaire, - = no data available.



CHAPTER

6

Return on Investment of the Back At Work After Surgery (BAAS) care pathway compared to care-as-usual in knee arthroplasty

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Abstract

Purpose: The Back At work After Surgery (BAAS) care pathway integrates medical and occupational care to enhance return to work (RTW) after knee arthroplasty (KA). BAAS has shown effectiveness in improving RTW outcomes, but its economic impact is unknown. This study evaluates the costs and return on investment (ROI) of BAAS compared with care-as-usual.

Methods: This multicenter, prospective cohort study involved 270 employed patients having KA, comparing the BAAS pathway (n=137) to care-as-usual (ACTIVE trial, n=133). The ROI was evaluated from societal and employer's perspectives. Productivity (absenteeism and presenteeism) and healthcare (primary and secondary) costs were assessed using cost questionnaires administered at 3, 6, 9 and 12 months post-surgery. Propensity score matching and multiple imputation addressed non-randomization and missing data, respectively. ROI was calculated by dividing the netto benefits—defined as reductions in productivity and healthcare costs, or productivity costs alone minus costs of the BAAS intervention—by the intervention costs multiplied by 100%.

Results: Propensity score matched analyses included 102 patients per cohort. The total netto benefits from employers and societal perspective were of €4,493 and €4,982, respectively. Intervention costs were €845/patient. This resulted in a ROI of 590% (95%CI 67% to 1,112%) and 532% (95%CI: 27% to 1,037%) from the societal and employer's perspective, respectively, per euro invested.

Conclusions: The BAAS care pathway demonstrates a favorable economic impact through significant 12 month downstream reductions in absenteeism and healthcare costs, and a positive ROI from both the societal and employer perspective.

Trial registration: This study was retrospectively registered at clinicaltrials.gov (<https://clinicaltrials.gov/ct2/show/NCT05690347> , date of first registration: 19-01-2023).

Key words: Return on investment, Orthopedic Procedures, Rehabilitation, Occupational Medicine, Knee, Arthrosis.

Statements and Declarations: All authors declare no competing interests. This study was funded by ZonMw (reference ID: 10320052010006).

Introduction

Work participation is a key determinant of individual health and well-being, yet it is often overlooked in clinical practice and research.¹⁻⁶ Return to work (RTW) after surgery is particularly relevant for individuals having knee arthroplasty (KA), as the incidence of KA is rising, especially among working-age patients.⁷⁻¹¹ Despite favorable outcomes in terms of pain relief and knee function, RTW rates following KA remain suboptimal, with global non-RTW rates reaching 35%.¹² In the Netherlands, approximately 31% of patients do not RTW after KA, contributing to a substantial socioeconomic burden.¹³ The average annual cost of sick leave related to knee osteoarthritis in the Dutch workforce has been estimated at €26.9 million, underscoring the need for effective interventions that facilitate timely and sustained RTW.¹⁴

Traditionally, postoperative care pathways for KA have prioritized medical and functional recovery, with limited attention to occupational reintegration. However, growing evidence suggests that integrating medical and occupational care can enhance RTW outcomes.¹⁵⁻²⁰ Interdisciplinary multimodal approaches, with coordinated modalities, such as rehabilitation, occupational support, and personalized guidance, have demonstrated effectiveness in reducing sick leave duration in other musculoskeletal conditions, but not surrounding KA. In response to this gap in KA care, the Back At work After Surgery (BAAS) clinical pathway was developed and tested on feasibility.^{21,22} BAAS emphasizes the early and structured integration of medical and occupational care, with a patient-centered approach that actively involves individuals in their RTW process. In previous studies, BAAS has demonstrated feasible and effectiveness on RTW outcomes without compromising clinical outcomes: more patients (98% versus 87-84%) started RTW earlier (16-25 days) and did fully RTW earlier (27 days). However, its economic impact remained unexamined.²⁰

This study aimed to evaluate the costs and return on investment (ROI) of the BAAS care pathway compared with care-as-usual from both the societal and employer's perspective. By addressing a critical economic gap in KA care and rehabilitation, this study may provide financial support for work-integrated perioperative care that could be extended to other surgical populations if proven economic viable.

Method

Study design

We conducted a multicenter prospective cohort study evaluating the costs and ROI of BAAS compared to a matching care-as-usual cohort from the ACTIVE trial.^{22,23} Ethical approval for the study was granted (reference IDs: 108 W21_454#21.504 and L1429.2021). This economic evaluation is reported according to the Consolidated Health Economic Reporting Standards 2022 (CHEERS 2022).²⁴

Study population, setting and location

Inclusion and exclusion criteria were similar for both cohorts (Table I). The recruitment procedure for BAAS is described in the protocol paper.²² The BAAS study was performed in two hospitals in the Netherlands, Nij Smellinghe Hospital (NS) and Elizabeth Tweesteden Ziekenhuis (ETZ). These hospitals perform approximately 450 and 600 KAs annually. The patients in the care-as-usual cohort from the ACTIVE trial were recruited in eleven Dutch clinics and hospitals, performing 100-800 KAs annually.²³

Table I: Inclusion and exclusion criteria, outcomes and covariates of the BAAS intervention and ACTIVE care-as-usual cohorts.

Cohort	Back At work After Surgery intervention	ACTIVE care-as-usual
Inclusion	Nov. 2021 to Apr. 2023	Oct. 2020 to Jan. 2023
Follow-up	Twelve months	Twelve months
Inclusion criteria	1. Primary UKA or TKA 2. Age 18 – 65 years 3. Paid work for at least 8 hours/week 4. Intention to RTW	1. Primary UKA or TKA 2. Age 18 – 67 years 3. Paid work for at least 8 hours/ week 4. Intention to RTW
Exclusion criteria	1. Receiving more than one medical event affecting workability within one year 2. KA for reasons other than knee osteoarthritis 3. Major disabling mental disorders 4. Not returning any of the sent cost-questionnaire	1. Another planned joint replacement during the study period 2. Extreme comorbidity affecting recovery 3. Not returning any of the sent cost-questionnaire
Primary outcomes and covariates		
- Primary outcomes	The costs of: - BAAS intervention - productivity loss (absenteeism and presenteeism) - health care (primary and secondary)	The costs of: - productivity loss (absenteeism and presenteeism) - health care (primary and secondary)
- Covariates	1. Sex 2. BMI 3. Type of surgery 4. Knee straining job 5. Sick leave 6. Work-relatedness of KA	1. Sex 2. BMI 3. Type of surgery 4. Knee straining job 5. Sick leave 6. Work-relatedness of KA

BAAS intervention

The BAAS intervention is extensively described in our protocol paper.²² To incorporate patient and public involvement, patients who had previously had KA were consulted in the early development of the BAAS care pathway and assessed the feasibility of the intervention.²¹ The BAAS care pathway started with a preoperative consultation by a hospital-based physical therapist. The patients were counseled for optimal preparation before surgery. Also, the patients completed several standardized questionnaires and performed functional tests to set a baseline measurement, which were used for evaluating clinical recovery. A work-related therapy goal was set using Goal Attainment Scaling (GAS). Patients were asked to wear an accelerometer from 2-weeks preoperatively until full RTW was achieved (PAM 2.0, PAM B.V., Oosterbeek, the Netherlands) to monitor physical activity with real-time feedback accessible to patients and healthcare professionals via the Atris app (Peercode, Geldermalsen, the Netherlands). An occupational assessor compiled a report of beneficial and limiting factors regarding RTW based on a preoperative workplace assessment (Appendix I).

Standard postoperative consultations by the hospital were organized at 6 weeks and every 3 months thereafter, up to 12 months or until full RTW was achieved. During these consultations, recovery was assessed by monitoring the GAS goal, and by using the same questionnaires and functional tests as those at baseline. Around the fourth or fifth week after surgery, an online team meeting was held involving the patient, primary care physical therapist, hospital-based physical therapist, occupational assessor, and occupational physician. This consultation focused on evaluating the recovery progress and to use this information to refine the RTW plan, if necessary.

Postoperative care included targeted exercise therapy by a physical therapist in a primary care setting, adhering to the Royal Dutch Society for Physiotherapy guidelines for knee osteoarthritis.²⁵ If the hospital-based physical therapist expected that a patient could not RTW within 12 months—based on patient experience, clinical assessments, and accelerometer data—patients were referred for a multidisciplinary rehabilitation assessment in an academic hospital. This assessment could lead to participation in a vocational rehabilitation program.

Care-as-usual

Patients receiving care-as-usual followed standard pre- and postoperative procedures following the protocols established by their treating hospital or clinic.²⁶ According to the Dutch Orthopaedic Association (NOV) guidelines, standard care for KA patients primarily includes surgical implantation of the knee prosthesis. This is preceded by a preoperative consultation conducted

by a surgeon or physician assistant and complemented by pharmacological management, such as antibiotics and pain relief medication. After surgery, patients have clinical follow-ups, primarily focusing on wound healing and assessing implant placement. This routine care is fully reimbursed by the Dutch healthcare system. Physical rehabilitation may be provided postoperatively, depending on the patient's individual circumstances and insurance coverage. Additionally, patients typically have access to hospital-provided eHealth tools, such as mobile applications (e.g., Patient Journey App) or websites. These digital resources commonly provide appointment schedules, contact details, guidance on wound care, and sometimes general rehabilitation exercises. Notably, these medical care and eHealth tools do not specifically address guidance on returning to work postoperatively.

Parallel to the medical process, working patients in the Netherlands are legally supported by the Gatekeeper Improvement Act, which mandates early and structured RTW guidance after sick leave. Employers and occupational physicians are required to collaborate on a reintegration plan within six weeks of sick leave. The occupational physician evaluates work capacity and facilitates graded work resumption. In more complex cases, an occupational assessor may be involved to assess job demands, possibilities for workplace adaptations, or options for job transfers, often offered one year after sick leave. However, orthopedic care including rehabilitation and occupational support are typically not well integrated, and RTW is not a standard focus within usual perioperative orthopedic care.

Measures

Outcome

Costs were measured from the societal and employer's perspective. From the societal perspective, costs included those of the BAAS intervention, healthcare utilization and productivity losses (absenteeism and presenteeism). When the employer's perspective was applied, healthcare costs were excluded as – in the Dutch situation – these do not accrue to the employer.

The cost of the BAAS intervention were estimated by collecting detailed data on its soft- and hardware costs as well as the time investments of the intervention providers, and valuing them using Dutch standard costs as provided by the Dutch Manual of Costing ²⁷. The other cost categories were assessed in both cohorts using cost questionnaires administered at 3, 6, 9 and 12 months follow-up. Absenteeism and presenteeism were measured using iMTA Productivity Cost Questionnaire (iPCQ) -based questions, valued using the average hourly cost of

labor in the Netherlands and the human capital approach.²⁸ The latter means that productivity losses due to absenteeism and presenteeism were valued based on the total number of hours not worked, multiplied by the average hourly wage. Healthcare utilization consisted of the use of primary care (e.g. physical therapist, general practitioner) and secondary care (e.g. hospital stay, medical specialist). Primary and secondary care were valued using Dutch standard costs as provided by the Dutch Manual of Costing, and if unavailable, prices of professional organizations. Costs were expressed in Euros and 2023 was used as reference year.

Demographics

Data on age, sex, BMI, type of surgery and comorbidities were obtained from the electronic medical patient file. Working hours per week, physical demands of the job, preoperative sick-leave, being breadwinner, level of education and being self-employed were asked to the patient in the preoperative consultation.

Statistical methods

To account for missing data and the non-randomized nature of the study, analyses were conducted using multiple imputation and nearest neighbor matching based on propensity scores, respectively. First, missing data in cost outcomes and relevant covariates were handled using Predictive Mean Matching (PMM) via the mice package in R. Five imputed datasets were created. Next, propensity scores were estimated for all patients in both cohorts using logistic regression based on prognostic factors for RTW. The latter was done because cost differences were mainly expected to arise from absenteeism and presenteeism. The following covariates were included: sex (female vs. male), type of surgery (UKA vs. TKA), BMI, physical job demands (knee straining vs. non-knee straining), preoperative sick leave (yes vs. no), and the self-reported work-relatedness of the knee complaint (ranging from “totally agree” to “totally disagree”). These propensity scores were used to perform nearest neighbor matching with a caliper width of 0.1, ensuring sufficient balance between groups. We evaluated the quality of the matching procedure by visualizing with propensity score density plots, using standardized mean differences and variance ratios, with thresholds of <0.1 and <2 respectively. After matching, differences in cost outcomes between groups were tested using paired t-tests appropriate for matched data. Such a parametric frequentist approach was chosen, as research shows that even when data are heavily skewed—accurate standard errors can be obtained when using parametric frequentist approaches in datasets with moderate to large sample sizes²⁹. Then, the ROI of the intervention was calculated as:

$$ROI = \frac{Netto\ benefits}{Costs} * 100\%$$

where *Netto benefits* were defined as reductions in productivity and healthcare costs (societal perspective) or productivity costs alone (employer's perspective) minus costs of the BAAS intervention, and *Costs* as the costs of the BAAS intervention. Please note that, in contrast to cost differences, positive *Netto benefits* indicate reduced spending. The ROI indicates the percentage of profit per Euro invested in the BAAS intervention, with positive ROIs indicating reduced spending.^{30,31} Economic analyses including ROI are calculated over a period of 12 months after surgery. The script used in R is presented in Appendix II.

Sensitivity analysis

Three sensitivity analyses were conducted; 1) applying Classification and Regression Tree (CART) instead of Predictive Mean Matching (PMM) for multiple imputation, 2) using a less restrictive matching strategy by increasing the caliper from 0.1 to 0.2, thereby accepting a less optimal match and 3) applying the statistical method on the complete cases without imputation.

Results

A total of 270 patients (BAAS: n=137, ACTIVE: n=133) were included for this study (figure 1) between November 2021 and April 2024. Missing data on BMI (n=4), preoperative sick leave (n=3), presenteeism at 3/6/9/12 months post-surgery (n=39/35/39/39), cost absenteeism (n=8), cost primary/secondary care (n=40/40) were imputed in a total of 93 patients (BAAS n=40, ACTIVE n=53). Prior to matching, patients in the intervention and care-as-usual cohort did not differ significantly in age, sex, comorbidities, breadwinner, BMI, or pre-operative sick leave. The cohorts did differ in level of education, type of surgery and knee straining jobs (table 2). After matching, n=102 were included for analysis per cohort. Covariate balance before and after matching was assessed using standardized mean differences and variance ratios, with thresholds of <0.1 and <2 respectively, indicating adequate balance across all covariates after matching (Appendix IV). Figure 2 shows substantial overlap of the propensity-score distributions for the BAAS and care-as-usual cohorts, indicating that the matching procedure achieved good balance on the measured baseline covariates.

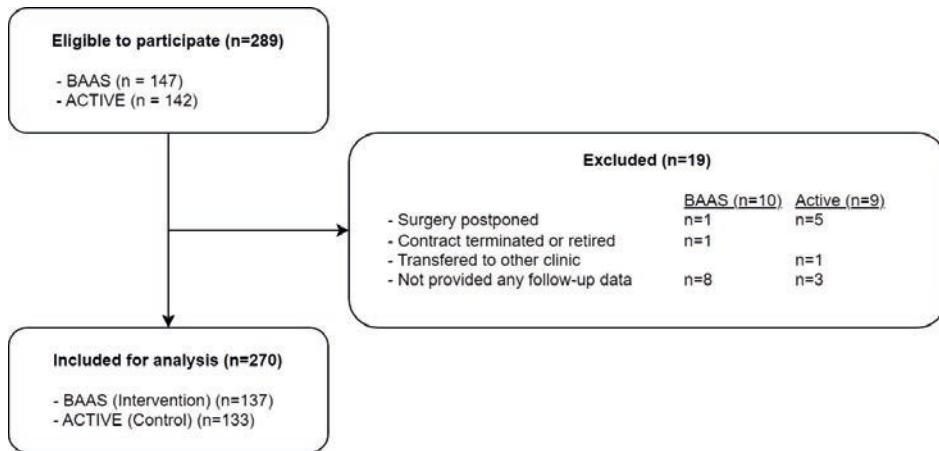


Figure 1: Flowchart

Table 2: Patient characteristics

	Before matching			After matching		
	BAAS (n=137)	Care-as- usual (n=133)	Difference (p)	BAAS (n=102)	Care-as- usual (n=102)	Difference (p)
Age (mean (SD))	58.5 (4.3)	58.7 (4.4)	0.581	58.1 (4.4)	58.9 (4.4)	0.232
Sex (%):			0.913			0.779
- Female	73 (53.3)	69 (51.9)		54 (52.9)	57 (55.9)	
- Male	64 (46.7)	64 (48.1)		48 (47.1)	45 (44.1)	
Education (%):			<0.001			0.004
- No	2 (1.5)	0 (0)		2 (2.0)	0 (0.0)	
- Primary	29 (21.2)	11 (8.3)		24 (23.5)	11 (10.8)	
- Lower secondary	72 (52.6)	59 (44.4)		50 (49.0)	48 (47.1)	
- Higher secondary	12 (8.8)	9 (6.8)		7 (6.9)	5 (4.9)	
- Higher vocational	18 (13.1)	48 (36.1)		15 (14.7)	34 (33.3)	
- University or higher	1 (0.7)	6 (4.5)		1 (1.0)	4 (3.9)	
Comorbidities (%):			0.083			0.069
- 0	109 (72.6)	103 (77.4)		80 (78.4)	77 (75.5)	
- 1	20 (14.6)	20 (15.0)		15 (14.7)	16 (15.7)	
- >1	4 (2.9)	10 (7.5)		3 (2.9)	9 (8.8)	
Breadwinner (%):			0.105			0.104
- Yes	58 (42.3)	52 (39.1)		44 (43.1)	41 (40.2)	
- No	75 (54.7)	81 (60.9)		54 (52.9)	61 (59.8)	
Type of surgery			0.040			1.000
- UKA	30 (21.9)	45 (33.8)		29 (28.4)	28 (27.5)	
- TKA	107 (78.1)	88 (66.2)		73 (71.6)	74 (72.5)	
BMI (mean (SD))	29.2 (3.9)	29.7 (4.0)	0.293	29.3 (3.8)	29.4 (4.0)	0.801
Knee straining job (%):			0.001			1.000
- Yes	67 (48.9)	38 (28.6)		67 (65.7)	68 (66.7)	
- No	70 (51.1)	95 (71.4)		35 (34.3)	34 (33.3)	
Sick leave before surgery (%):			0.134			0.865
- Yes	30 (21.9)	27 (20.3)		81 (79.4)	79 (77.5)	
- No	107 (78.1)	106 (79.7)		21 (20.6)	23 (22.5)	

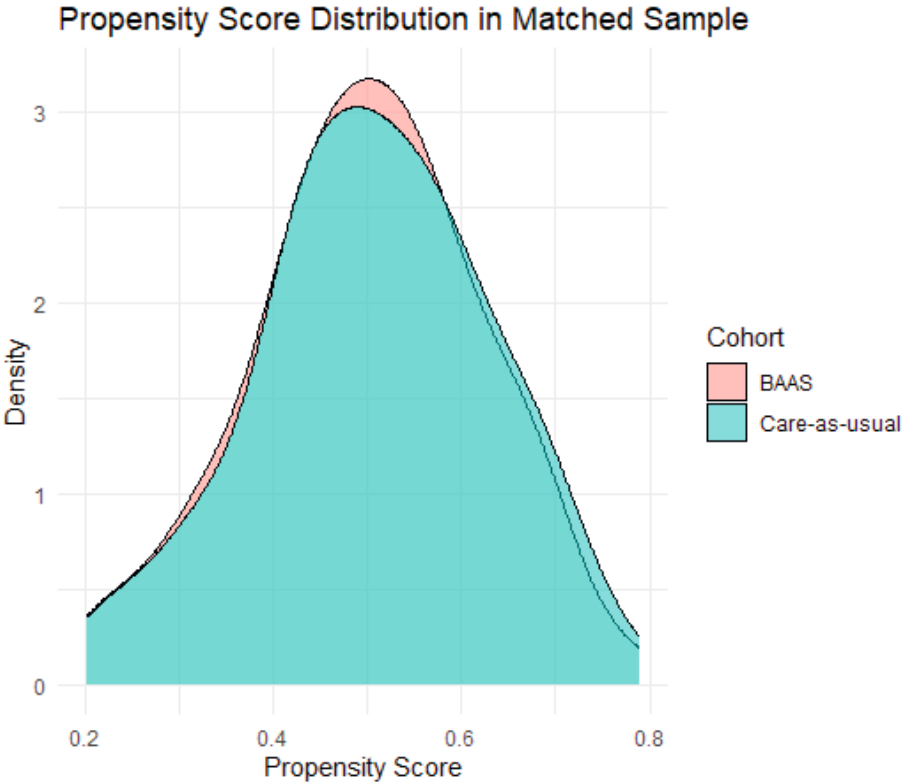


Figure 2: Propensity score density plot

Costs

The costs for the BAAS intervention were €845 per patient (movement sensor €60, occupational physician €128, occupational assessor €375, physical therapist hospital €242 and physical therapist primary care €40). Since no patients entered vocational rehabilitation, these costs were excluded. Differences in primary care (-€489) and absenteeism (-€7,263) were statistically significant, resulting in a significant difference from the employers and societal perspective of -€4,493 and -€4,982, respectively, in favor of the intervention group (table 3). The distribution of costs is presented in violin plots in Appendix III.

Return on investment

The total netto benefits from employers and societal perspective were of €4,493 and €4,982, respectively in the intervention cohort. The costs of the intervention were €845 per patient, resulting in an ROI of 590% [95%CI: 67% - 1,112%) from the societal perspective and 532% [95%CI: 27% - 1,037%] from the employer's perspective per invested euro (table 3).

Table 3: Costs of the Back At work After Surgery care pathway versus care-as-usual

Costs	Costs BAAS [95% CI]	Costs CAU [95% CI]	Difference
Intervention BAAS	€845	-	€845
Medical Care	€3,226 [2,917 – 3,535]	€3,715 [3,366 – 4,064]	€489 [26 – 953]
- Primary	€1,407 [1,179 – 1,636]	€1,847 [1,551 – 2,143]	€440 [68 – 812]
- Secondary	€1,819 [1,662 – 1,975]	€1,868 [1,745 – 1,991]	€49 [-149 – 247]
Productivity loss	€26,375 [23,923 – 28,827]	€31,713 [28,192 – 35,233]	€5,338 [1,070 – 9,605]
- Absenteeism	€15,900 [13,895 – 17,905]	€23,163 [19,099 – 27,227]	€7,263 [2,749 – 11,777]
- Presenteeism	€10,475 [8,986 – 11,964]	€8,550 [6,938 – 10,162]	€1,925 [-256 – 4,107]
Total employer's costs	€27,220 [24,768 – 29,672]	€31,713 [28,192 – 35,233]	€4,493 [225 – 8,760]
Total societal costs	€30,446 [27,897 – 32,995]	€35,428 [31,792 – 39,065]	€4,982 [565 – 9,399]

Sensitivity analysis

The first sensitivity analyses, using CART imputation showed results still in favor of BAAS, though the differences were less pronounced. Specifically, difference in societal costs were -€4,430 [95%CI: -8,507 to -353] compared to -€4,982 [95%CI: -9,399 to -565] in the main analysis, and difference in productivity loss costs were -€3,991 [95%CI: -8,208 to 225] compared to -€5,338 [95%CI: -9,605 to -1,070]. In the second sensitivity analysis, using a less optimal matching strategy (caliper of 0.2, resulting in n=107 matched pairs), the results were similar, albeit slightly less pronounced: total societal costs difference of -€3,206 [95%CI: -7,369 to 958] and productivity loss costs difference of -€3,666 [95%CI: -7,686 to 355]. In the third sensitivity analysis, we repeated the matching and cost comparison in the complete case sample (n = 177). The BAAS group showed a cost difference of €2,814 (95% CI -€1,703 to €7,332, p = 0.220) in productivity loss and €2,409 (95% CI -€2,297 to €7,116, p = 0.313) in total societal cost compared to care-as-usual.

Discussion

Key results

This study demonstrated that implementing the BAAS intervention yielded, on average, a positive financial return for both the employer (€4,493) and society (€4,982) at large. Notably, the return on investment (ROI) for the employer was statistically significant, indicating that for every Euro invested in the intervention, the employer made a profit of 532%. Interestingly, presenteeism costs were non significantly higher in the BAAS group, which might be due to shorter absenteeism periods, causing patients to RTW earlier, but potentially with reduced productivity. This inverse relationship between absenteeism and presenteeism costs has also been noted in previous studies.^{32,33}

Comparison to current literature and future perspectives

Our findings align with existing literature highlighting the economic advantages of work-integrated interventions for musculoskeletal conditions. Work-integrated interventions after KA have demonstrated significant reductions in productivity loss, emphasizing the broader socioeconomic benefits of such strategies.^{34,35} Similar economic benefits have been observed in lumbar spine surgery, with reductions in absenteeism translating to substantial long-term savings.³⁶ Previous studies demonstrated the economic burden of knee osteoarthritis and KA, highlighting the importance of timely interventions.^{7,37} Abe et al. found that costs associated with nonoperative treatments in the year before KA often exceed the costs incurred after surgery, indicating potential inefficiencies of prolonged nonoperative management from an economic perspective.³⁷ However, our emphasis is not solely on earlier surgery, but rather on the timely and integrated coordination between medical and occupational care surrounding KA. Indeed, our findings show a positive return on investment mainly because the BAAS pathway resulted in 98% of patients successfully returning to full work following surgery instead of 13% in the care-as-usual cohort.²⁰ These results suggest an optimal balance between conservative management and timely surgical intervention, where work-related outcomes should be considered alongside clinical factors in decision-making. Similarly, our results are consistent with previous studies evaluating work-integrated interventions after KA. The Finnish Coordinated RTW (CRTW) program demonstrated positive effects on RTW, although the mean time to RTW (87 days) was notably longer than the median time in BAAS (27 days).^{18,19} Although these outcomes cannot be perfectly compared (mean vs. median), the difference is notable. Moreover, 13% of CRTW participants did not RTW within one year, compared to only 2% in our BAAS cohort.^{18,19} These differences may reflect the more structured and interdisciplinary design of BAAS, which integrates occupational guidance earlier in the perioperative trajectory. Future research should focus on the long-term occupational and economic outcomes of work-integrated care interventions like the CRTW study or BAAS, including exploring sustainability beyond the initial postoperative year and the role of personalized, adaptive approaches in optimizing RTW trajectories after surgery.

Strengths and limitations

Our study had several strengths. First, this study included a large number of patients in two hospitals and eleven hospitals/clinics, increasing generalizability. Second, the application of nearest neighbor matching enhances the internal validity of our findings by adjusting for baseline differences. Also, sensitivity analyses showed results in the same direction. Lastly, the applied methods are in line with the Dutch guidelines for economic evaluations in healthcare, published

by the National Health Care Institute of the Netherlands, ensuring methodological rigor and relevance for policy-making.²⁷

Our study had several limitations. First, presenteeism was measured using a questionnaire based on the IPCQ, wherein patients were asked about the number of days at work with reduced productivity over the past three months, which differs from reliably measuring reduced production at work.³⁸ Although measuring productivity remains subject to debate³⁹, presenteeism was assessed identically in both cohorts, minimizing systematic bias. Second, the study was conducted in the Netherlands, which may limit the generalizability of findings to other healthcare and workplace disability policies and reimbursement models. Third, the BAAS intervention cohort contained proportionally more participants with a lower level of education, even after matching (table 2). Lower level of education has been linked to slower functional recovery and a longer time to RTW after KA.⁴⁰⁻⁴³ Because education is highly correlated with physical job demands, we included only the “knee-straining job” variable in the propensity model to avoid multicollinearity, and this characteristic was balanced between groups. Residual confounding by education can therefore not be ruled out; if lower-educated workers indeed face a poorer prognosis, however, the current cost advantage observed for BAAS is likely an underestimate compared to a better education-balanced situation. In addition, patients with ≥ 2 comorbidities were over-represented in the care-as-usual cohort after matching, raising the possibility of residual confounding through multimorbidity-related cost inflation. Future studies should quantify the independent impact of educational level and multimorbidity on post-operative societal and employer costs after knee arthroplasty, to determine the extent of residual confounding in economic evaluations like ours. Fourth, our cost analysis did not include the one-off implementation expenses that hospitals incur when establishing a BAAS pathway from scratch—such as staff training, development of local protocols, and the purchase or leasing of monitoring devices (e.g., accelerometers). Although these start-up costs are non-recurring and diminish once BAAS is embedded, they would reduce the net financial gain in the first year of roll-out. Consequently, hospitals and clinics that are adopting BAAS de novo are unlikely to realize the reported ROI within their initial implementation year. In addition, workplace accommodations were advised by the occupational assessor if needed, but were not recorded in this study. As a result, this may have influenced productivity-related costs, potentially leading to an overestimation of the employer's ROI. Lastly, we limited the follow-up to 12 months post-surgery. This one-year timeframe may be insufficient to capture the long-term sustainability of BAAS benefits. Any late-occurring costs or relapses into sick leave beyond the first year were not assessed, leaving uncertainty about the durability

of the economic impact over multiple years. Because the BAAS cohort achieved a higher RTW rate than the care-as-usual cohort (98 % vs 87 %), and Dutch employers must continue paying wages during the first two years of sick leave, the true employer cost differential is likely larger than the estimate reported in this study²⁰. Moreover, as demonstrated by Zaballa et al., some patients who have KA initially successfully RTW but subsequently exit employment due to persistent knee-related problems, underscoring the importance of monitoring longer-term occupational outcomes.⁴⁴

Conclusion

By combining medical and occupational care, the BAAS work-integrated care pathway reduces overall costs, costs of productivity loss and medical costs after KA, yielding a positive ROI from employers and societal perspective.

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Declaration of interest

The authors have no relevant financial or non-financial interests to disclose.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by DO Strijbos, PPFM Kuijer and AC Straat. The first draft of the manuscript was written by DO Strijbos and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request

Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of University of Amsterdam (28/10/2021, reference W21_454 # 21.504). Informed consent was obtained from all individual participants included in the study.

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Supplementary file (appendices)

The supplementary file can be downloaded using the QR code below.





CHAPTER

7

Prognostic factors for return to work following knee arthroplasty (Protocol)

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Abstract

Objectives - This is a protocol for a Cochrane Review (prognosis). The objectives are as follows: We will examine four prognostic factors for return to work that can be used to manage patient expectations, enhance shared decision making, and improve timely, multidisciplinary, work-directed care.

The research question - Which of the following four prognostic factors, categorised according to the International Classification of Functioning, Disability and Health (ICF) framework, are associated with return to work after primary knee arthroplasty in patients with a paid job: type of arthroplasty (health condition), sick leave before surgery (participation), physically demanding work (environmental factors), and patient expectations regarding return to work (personal factors)?

PICOTS - We define our PICOTS as:¹

- Patients (P): individuals engaged in paid employment who actively choose primary total knee arthroplasty or unicompartmental knee arthroplasty as a treatment option for knee osteoarthritis.
- Index prognostic factors (I): we will consider these prognostic factors.
 - Type of arthroplasty
 - Duration of sick leave prior to surgery
 - Engagement in physically demanding work
 - Person's expectations regarding recovery
- Comparator (C):
 - Type of arthroplasty: unicompartmental knee arthroplasty versus total knee arthroplasty
 - Duration of sick leave prior to surgery: short-term versus long-term
 - Engagement in physically demanding work: light versus medium and heavy knee-demanding work
 - Patient expectations regarding recovery: positive versus negative

- Outcomes (O): the primary outcome is the return to work, which is further classified by:
 - Nature of return to work: initial, full, or undefined;
 - Method of measurement:
 - o Dichotomous (yes/no): short- and long-term return to work;
 - o Scale: duration of return to work.
- Time (T): prognostic factors will be assessed preoperatively. The outcome, i.e. return to work, is measured as dichotomous data (short and long-term) and on a scale.
 - Short-term (6 months post-surgery)
 - Long-term (> 6 months but not exceeding 36 months post-surgery)
 - Duration until return to work
- Setting (S): range of hospitals and clinics, social security and healthcare systems from multiple countries

Background

Knee replacement surgery or knee arthroplasty is the preferred treatment of choice for people with end-stage knee osteoarthritis.

In the upcoming decades, there will be a steep rise in demand from people seeking knee replacement surgery. For instance, in Australia, an increase of 276% is expected (2013 to 2030); in the Netherlands, the increase is expected to be 297% (2005 to 2030).² The largest increase in osteoarthritis is expected amongst people of working age.³ The good clinical outcomes of knee arthroplasty, the obesity epidemic, and the rising pension age help to explain the shift towards working people.³ In several countries, the proportion of people under 65 years who undergo knee arthroplasty is already substantial, i.e. 30% to 40%.^{2,4-9}

Description of the health condition and context

For young people undergoing knee arthroplasty, who are most often still active at work and in their social activities, societal participation is of the utmost importance, and returning to work after knee arthroplasty is likely the most important participation goal for many.¹⁰ Since most people consider work a source of social capital and social support, societal participation and return to work after knee arthroplasty are important predictors of a good quality of life.¹⁰

However, despite the good clinical outcomes of pain relief and improved knee function after knee arthroplasty, recent studies show that return to work outcomes are poor. About 40% of people with preoperative employment who receive knee arthroplasty do not return to work within six months, and one third do not return to work at all.¹¹ The current standard postoperative care after knee arthroplasty is not targeted towards work participation.¹²⁻¹⁷ Usual care for people eligible for knee arthroplasty is typically limited to the surgical placement of an implant. It may be supplemented with:

- a presurgical evaluation by the surgeon, physician assistant, or both;
- pharmaceutical treatment, such as anti-inflammatory, antibacterial, or pain relief medication;
- postsurgical clinical check-ups, mainly targeted at implant position and wound healing;
- depending on the individual's insurance, physical therapy to regain functional recovery and optimal joint mobility.

Consequently, the current usual care includes no evidence-based clinical pathway for return to work after knee arthroplasty.

Clinicians lack the training, awareness, and disease-specific evidence in clinical guidelines to enable them to assist in guiding return to work after knee arthroplasty. Knowledge of the prognostic factors that influence return to work might help to manage patients' expectations, enhance shared decision-making, and improve multidisciplinary work-directed care by healthcare professionals who provide rehabilitation.

Therefore, we will conduct a systematic review to identify four prognostic factors for return to work after knee arthroplasty, as described in the peer-reviewed medical literature. This information is useful in clinical practice. As an example, Pahlplatz and colleagues examined participants' perspectives on beneficial and limiting factors that influenced their return to work after total knee arthroplasty. They concluded that incorporating return to work in the clinical pathway could result in more accurate and personalised rehabilitation.¹⁷

In this review, we aim to explore these prognostic factors, including the strength of these factors, for return to work after knee arthroplasty: type of arthroplasty, duration of sick leave before surgery, physically demanding work, and patient expectations regarding recovery. We hope our results will add knowledge about clinically-relevant prognostic factors that can be used to manage patient expectations, enhance shared decision-making, and improve timely, multidisciplinary, work-directed care. For instance, on an individual level, a patient can be informed about the likelihood of returning to work, and the factors that might enhance or hinder his/her return. Realistic work-directed goals can then be discussed and set. People at risk of a delayed return to work might receive additional work-directed care, for example, a timely referral to an occupational or physical medicine and rehabilitation physician, as indicated. Prognostic factors for return to work can also be used at a population level, by incorporating this information into guidelines for knee arthroplasty rehabilitation.

Why it is important to do this review

There has been a substantial increase in knee arthroplasty amongst the working-age population. Systematic reviews by Pahlplatz and colleagues and Tilbury and colleagues found a wide range in the time it took different people to return to work, indicating that prognostic factors play an important role.^{18,19} In order to narrow this range, more attention should be given to the prognostic factors involved. Appropriate advice, care, and guidance can be aimed at modifiable

prognostic factors, such as patients' expectations for recovery, to improve timely work participation.

A recent systematic review identified a number of prognostic factors affecting return to work after total knee arthroplasty: physical nature of employment, preoperative absence from work, flexible work conditions, older age, being self-employed, age less than 45 years in a military population, level of education, functional outcome of total knee arthroplasty, change in Knee Osteoarthritis Outcome Score (KOOS) sport subscale score from baseline, good self-rated health.²⁰

Our review will expand upon Leemput 2022.²⁰

- Due to the increasing prevalence of people with unicompartmental knee arthroplasty, especially in the working-age population, we will expand the search to include unicompartmental knee arthroplasty (Price 2018).
- We will differentiate between three return to work outcomes (yes/no in the short- and long-term, time to first return to work, and time to full return to work) and report those separately.
- We will not include systematic reviews or qualitative studies. However, we will check the references of systematic reviews and qualitative studies identified during our search for potential relevant articles.
- We will undertake a more comprehensive search, based on a validation set of references, to capture eligible studies they failed to include (e.g. Clyde 2013²¹; Kuijer 2016²²; Sankar 2013²³). See our preliminary study selection in Appendix 1.
- If possible, we will perform a meta-analysis to calculate reliable and valid estimates of the strength of similar prognostic factors.

Objectives

We will examine four prognostic factors for return to work that can be used to manage patient expectations, enhance shared decision-making, and improve timely, multidisciplinary, work-directed care.

The research question

Which of the following four prognostic factors, categorised according to the International Classification of Functioning, Disability and Health (ICF) framework,

are associated with return to work after primary knee arthroplasty in patients with a paid job: type of arthroplasty (health condition), sick leave before surgery (participation), physically demanding work (environmental factors), and patient expectations regarding return to work (personal factors)?

PICOTS

We define our PICOTS as:¹

- Patients (P): individuals engaged in paid employment who actively choose primary total knee arthroplasty or unicondylar knee arthroplasty as a treatment option for knee osteoarthritis.
- Index prognostic factors (I): we will consider these prognostic factors.
 - Type of arthroplasty
 - Duration of sick leave prior to surgery
 - Engagement in physically demanding work
 - Person's expectations regarding recovery
- Comparator (C):
 - Type of arthroplasty: unicondylar knee arthroplasty versus total knee arthroplasty
 - Duration of sick leave prior to surgery: short-term versus long-term
 - Engagement in physically demanding work: light versus medium and heavy knee-demanding work
 - Patient expectations regarding recovery: positive versus negative
- Outcomes (O): the primary outcome is the return to work, which is further classified by:
 - Nature of return to work: initial, full, or undefined;
 - Method of measurement:
 - Dichotomous (yes/no): short- and long-term return to work;
 - Scale: duration of return to work.
- Time (T): prognostic factors will be assessed preoperatively. The outcome, i.e. return to work, is measured as dichotomous data (short- and long-term) and on a scale.
 - Short-term (≤ 6 months post-surgery)
 - Long-term (> 6 months but not exceeding 36 months post-surgery)
 - Duration until return to work
- Setting (S): range of hospitals and clinics, social security and healthcare systems from multiple countries

Methods

Description of the prognostic factors

As described, a steep rise in the number of knee arthroplasties is expected in the coming years. The largest increase of people most likely to receive knee arthroplasty will be people of working age. We will assess four preoperative prognostic factors for return to work amongst people after knee arthroplasty, including an evaluation of the strength of the association, which are based on previous reviews.¹⁸⁻²⁰

We categorised them according to the World Health Organization's International Classification of Functioning, Disability and Health (WHO-ICF). Our hypothesis is that outcomes marked with (+) are prognostic factors that positively influence return to work.

- Health condition: type of arthroplasty (unicondylar knee arthroplasty (+) versus total knee arthroplasty)
- Participation: sick leave before surgery (short-term (+) versus long-term)
- Environmental factors: physically demanding work (light (+) versus medium and heavy knee-demanding work)
- Personal factors: patient expectations regarding recovery (positive (+) versus negative)

Health outcomes

The primary outcome of interest is return to work following knee arthroplasty. The definition of the outcome is based on the nature of the return and the method of measurement.

Status of return to work

- Initial return to work: partial resumption of work
- Full return: complete resumption of work
- Undefined: status of return to work, initial or full, is not defined

Method of measuring return to work

- Longitudinal: duration of time from surgery to return to work
- Dichotomous:
 - Short-term: return to work within a period of six months post-surgery
 - Long-term: return to work after a period exceeding 6 months but not exceeding 36 months post-surgery

Considering these categorisations, we can identify nine distinct outcomes, which will be tabulated as follows:

	Duration of return	Short-term return	Long-term return
Initial return to work			
Full return to work			
Undefined			

We will focus on (societal) participation in this review. We will define work as any form of paid employment, regardless of the number of hours worked. We will define return to work as resuming the primary job (i.e. the same job held prior to the surgery), transitioning to a modified job, or taking a new job altogether.

Criteria for considering studies for this review

We will report the study selection process in a PRISMA flowchart.²⁴ We will provide details according to the Prognosis Research Strategy (PROGRESS) framework.²⁵

Studies must be published as peer-reviewed research articles, in a peer-reviewed journal, and the full text of the article must be available.

Types of studies

We will include cohort studies, both prospective and retrospective, and prognosis studies based on randomised controlled trials (RCT). There are no language restrictions.

Targeted population

We will include studies with participants who had a paid job prior to surgery, and who received a primary total or unicompartmental knee arthroplasty due to knee osteoarthritis.

We will include trials with a mixed population (e.g. osteoarthritis and trauma) if at least 70% of the participants have osteoarthritis as the indication for knee arthroplasty. If the data are presented separately for different indications, we will only include data from participants with osteoarthritis. If an indication for knee arthroplasty is not mentioned for the included participants in a study, we will include those papers, as we assume that osteoarthritis is the main indication for the majority of the participants.

We will exclude studies that report data on participants who were unemployed preoperatively, on participants who received a second or revision knee arthroplasty, or on participants who received other types of surgery.

Types of prognostic/predictive factor(s) or model(s)

The review will assess four prognostic factors described in the literature for return to work after knee arthroplasty, categorised according to the WHO-ICF: type of arthroplasty, sick leave before surgery, physically demanding work, and patient expectations regarding recovery.

Types of outcomes to be predicted

Our outcomes will be measured as either dichotomous (short- and long-term return to work) or longitudinal (time-to-return to work) measures.

Effect measures of the outcome, return to work, may be expressed as hazard ratios (HR), odds ratios (OR), risk ratios (RR), percentages, and mean or median differences, with measures of variation, such as standard deviation, interquartile range, or range (minimum to maximum). They will be calculated for short- and long-term postoperative time periods, up to a maximum of 36 months postoperative.

Search methods for identification of studies

Our search methods for identification of studies are specified below.

Electronic searches

Based on a validation set of references, and with the support of a clinical librarian, we will search these databases and trials registers.

Our search strategies are listed in Appendix 2.

- Cochrane Central Register of Controlled Trials (CENTRAL; current issue) in the Cochrane Library
- MEDLINE Ovid (1946 to search date)
- Embase Ovid (1974 to search date)
- US National Institutes of Health Ongoing Trials Register ClinicalTrials.gov (www.clinicaltrials.gov)
- World Health Organization International Clinical Trials Registry Platform (apps.who.int/trialsearch)
- EU Clinical Trials Register (www.clinicaltrialsregister.eu)

Searching other resources

We will snowball our search (screen all the articles that cite our included papers), check the reference list of all included articles, and conduct a forward citation search using Web of Science to identify studies missed from the original electronic searches.

Data collection

Selection of studies

Two review authors will independently screen all titles and abstracts using Rayyan.²⁶ DOS, ACS, and PPFMK will assess one third of the titles and abstracts each, and the other nine co-authors will assess one ninth each. If there is disagreement between the review authors during screening of the titles and abstracts, they will discuss to reach consensus. When consensus cannot be reached, a review author not originally assigned to that article will be consulted for a final decision. Review of the full-text reports will be completed by the same pair of review authors who reviewed the title and abstract.

We will exclude papers that do not examine the effect of our four prognostic factors. We will give reasons for exclusion at the full-text stage, and present them in a characteristics of excluded studies table. We will complete a PRISMA flowchart that includes the numbers of reports identified, included, and excluded.

Data extraction

We will extract basic characteristics from the included studies (Appendix 3):²⁷

- Source of data: study design (prospective/retrospective)
- Participants: inclusion and exclusion criteria of the study, participant characteristics (age, sex, year of arthroplasty, comorbidity, level of education)
- Outcomes to be predicted: how return to work was defined (initial, full, or undefined), measured (dichotomous/longitudinal), assessed (self-report measures versus register-based), and the corresponding return to work outcomes; number of participants resuming their primary job (i.e. the same job held prior to the surgery), transitioning to a modified job, or taking up a new job altogether; more or less working hours compared to pre-surgery
- Prognostic factors: type of arthroplasty, sick leave before surgery, physically demanding work, patient expectations regarding recovery
- Sample size: number of included participants, availability of sample size calculation
- Missing data: number of participants lost to follow-up
- Analysis: modelling methods
- Results: unadjusted and adjusted prognostic effect estimates. If multiple adjusted models are reported, we will include the fully adjusted model in our analysis.
- Interpretation and discussion (interpretation of present results)

The CHARMS-PF checklist was the starting point for our data extraction form, to which we added other relevant items (Appendix 3).²⁸ Two of three review authors (DOS, ACS, and PPFMK) will independently extract the data and compare results. If discrepancies arise during this discussion that cannot be resolved, the third review author will be consulted for a final decision. We will pilot test the data extraction form in two studies beforehand.

We will contact study authors to obtain missing or confirm unclear information to enhance precision and reduce the impact of reporting biases. Missing information might include risk of bias assessments, details of interventions and outcomes, or study results.

Assessment of risk of bias in included studies

Two review authors will independently assess the risk of bias for each included study and for each prognostic factor (three review authors (DOS, ACS, PPFMK) will assess one third of the studies each, and the other nine co-authors will assess one ninth each) using the Quality In Prognosis Studies (QUIPS) tool (Appendix 4).²⁹ Disagreement will be resolved by the two review authors who assessed the study. In the case of disagreement, a third review author will be consulted. We will pilot test the risk of bias assessment in two studies beforehand.

The QUIPS tool considers six domains: study participation, study attrition, prognostic factor measurement, outcome measurement, study covariates, and statistical analysis and reporting.²⁹ We added 'competing risks' to our risk of bias assessment. If competing risks are not reported or measured, we will assess the report at a higher risk of bias. We will extract relevant information from the study and note methodological considerations relevant to each domain. We will judge each domain and each prognostic factor as high, moderate, or low risk of bias.²⁹

Measures of association or predictive performance measures to be extracted

For dichotomous outcomes, we will extract the number and percentage of those returning to work in the short-term and long-term.

For longitudinal outcomes, we will extract the mean, median, standard deviation, interquartile range, and range.

We will extract these measures of association.²⁷

- Odds ratio (OR) or risk ratio (RR) from univariable or univariate models between the prognostic factor and the outcome, return to work (short-

or long-term), with 95% confidence interval (CI), or standard error (SE). If available, we will extract the actual number and percentage of participants who reported the prognostic factor, and returned to work.

- Hazard ratio (HR) from univariate or univariable models between prognostic factor and the outcome, time-to-return to work, with 95% CI or SE
- Adjusted OR or RR between the prognostic factor and the outcome, return to work (short- or long-term), with 95% CI or SE. If multiple adjusted ORs or RRs are reported, we will extract all of them.
- Adjusted HR between the prognostic factor and the outcome, time-to-return to work, with 95% CI or SE. If multiple adjusted HRs are reported, we will extract all of them.

For our dichotomous (short- and long-term) outcome, our preferred summary estimate is the RR. If RR is not mentioned, we will try to convert OR to RR. We will also calculate RR from percentages.

For the outcome 'time-to-return to work', our preferred summary estimate is the HR. If the data do not allow us to calculate the HR or RR, and if we are unable to obtain the data from the study authors, we will exclude the study with reason.

Dealing with missing data

If data are missing, we will contact the corresponding study author. If authors are unresponsive, we will note this in our review. We will include this in our risk of bias assessment, and exclude the study with reason if we are unable to proceed with our analyses.

Assessment of heterogeneity

We will examine clinical heterogeneity and statistical diversity amongst the included studies, since this may affect the overall prognosis. We will assess heterogeneity by calculating the I^2 statistic. We will visually inspect the forest plots, looking for overlap of point estimates and 95% CIs. We will explore the possible sources of heterogeneity through subgroup analysis.

Assessment of reporting deficiencies

We will conduct the review according to this published protocol, and report any deviations from it in the Differences between protocol and review section of the completed review. To assess publication bias, we will visually examine asymmetry in funnel plots if we include at least 10 studies.

Data synthesis

Data synthesis and meta-analysis approaches

We will pool the measures of association with meta-analyses, preferably using Review Manager's generic inverse variance Methods random-effects model.³⁰ We will report a separate meta-analysis for each type of association (i.e. unadjusted and adjusted), and our outcomes for each prognostic factor. We will present the data of the meta-analysis in forest plots for each comparison.

As previously mentioned, our preferred summary estimate is the RR for dichotomous (short- and long-term) outcomes, and HR for longitudinal outcomes. We will try to convert ORs and percentages into RRs.

We will create a Directed Acyclic Graph model to depict the prognostic factors and their relation with return to work.³¹

Subgroup analysis and investigation of heterogeneity

We will undertake subgroup analyses for risk of bias (low versus moderate and high), willingness to return to work, and care provided besides knee arthroplasty (e.g. additional pre- or postoperative rehabilitation) for the four prognostic factors. We presume that low risk of bias is the best estimate of the prognostic factors. We presume that willingness to return to work and additional rehabilitation will enhance return to work outcomes.

Sensitivity analysis

We will undertake a sensitivity analysis for the definition of three of the four prognostic factors: sick leave before surgery, physically demanding work, and patient expectations regarding recovery. We will not undertake a sensitivity analysis for the type of surgery, because we are of the opinion that the quality of the procedure and prosthesis implant are similar for unicondylar knee arthroplasty and for total knee arthroplasty regarding work participation. Therefore, we consider all participants with unicondylar knee arthroplasty similar; the same goes for participants with total knee arthroplasty.

Conclusions and summary of findings

We will describe the prognostic factors and the strength of association for return to work after knee arthroplasty, categorised according to the WHO-ICF. We will create a Directed Acyclic Graph model to visualise the relation between the prognostic factors and return to work.³¹

GRADE

We will use the GRADE framework to assess the overall certainty of evidence for prognostic factors for return to work after knee arthroplasty.³²

- High: we are very confident that the variation in risk associated with the prognostic factor (probability of future events in those with/without the prognostic factor) lies close to that of the estimate.
- Moderate: we are moderately confident that the variation in risk associated with the prognostic factor (probability of future events in those with/without the prognostic factor) is likely to be close to the estimate, but there is a possibility that it is substantially different.
- Low: our certainty in the estimate is limited; the variation in risk associated with the prognostic factor (probability of future events in those with/without the prognostic factor) may be substantially different from the estimate.
- Very low: we have very little certainty in the estimate; the variation in risk associated with the prognostic factor (probability of future events in those with/without the prognostic factor) is likely to be substantially different from the estimate.

Prospective observational studies

Prospective observational studies provide high-quality evidence for prognostic factors, and therefore, we will start with high certainty.³² The certainty will be downgraded by one level for risk of bias, inconsistency, imprecision, indirectness, and publication bias.³²⁻³⁵

- Risk of bias: the certainty of a prognostic factor is downgraded if most evidence is from studies with a moderate or high risk of bias for most of the QUIPS domains: study participation, study attrition, outcome measurement, study covariates, and statistical analysis and reporting.
- Inconsistency: the certainty of a prognostic factor is downgraded based on variability in point estimates using 95% CIs, extent of overlap of these intervals, large I^2 , and where point estimates lie in relation to clinically meaningful differences for return to work. We consider a 5% increase in return to work, and a return to work of seven working days earlier to be clinically relevant. We prespecified subgroup analysis, and will investigate heterogeneity to explore differences across categories. See Subgroup analysis and investigation of heterogeneity.

- Imprecision: the certainty of a prognostic factor is downgraded if the range of the 95% CI for a risk estimate is > 2.0 , or the lower bound of the 95% CI is not seen as a clinically meaningful difference for return to work.
- Indirectness: the certainty of a prognostic factor is downgraded if the prognostic factor is rated at high risk of bias for the QUIPS domain, prognostic factor measurement. We do not expect to downgrade for the selected population, because our inclusion criterion is people of working age with knee arthroplasty.
- Publication bias: the certainty of a prognostic factor is downgraded if publication bias is suspected, based on funnel plot representation, preferably supplemented with a Peter's test level or Egger's regression test.^{36,37}

Dose-response relationships

Certainty can be upgraded by one level for a large effect estimate and the presence of a dose-response relationship:

- Large effect estimate: the certainty of a prognostic factor is upgraded if a risk estimate is > 2.5 and the 95% CI is < 2 of a risk estimate, or a clinically meaningful large difference in the return to work outcome.
- Presence of dose-response relationship: the certainty of a prognostic factor is upgraded if the study reports an established dose-effect relationship.

Two review authors will independently grade the evidence and resolve differences by discussion, or by involving a third review author. We will construct a summary of findings table for each prognostic factor, to present our certainty of the evidence (Appendix 5).

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Editorial and peer-reviewer contributions

The Cochrane Work Group supported the authors in the development of this review.

The following people conducted the editorial process for this article:

- Sign-oQ Editor (final editorial decision): Jos Verbeek
- Managing Editor (selected peer reviewers, collated peerreviewer comments, provided editorial guidance to authors, edited the article): Jessica Thomas & Julitta Boschmann, Amsterdam UMC
- Information Specialist (literature search support): Faridi Jamaludin
- Copy-editing (initial copy-edit and final proofread): Victoria Pennick, Cochrane Central Production Service
- Peer reviewers: Alex Burdorf, Farid Faroutan, Karen Walker-Bone, Rachel Richardson, Anneke Damen

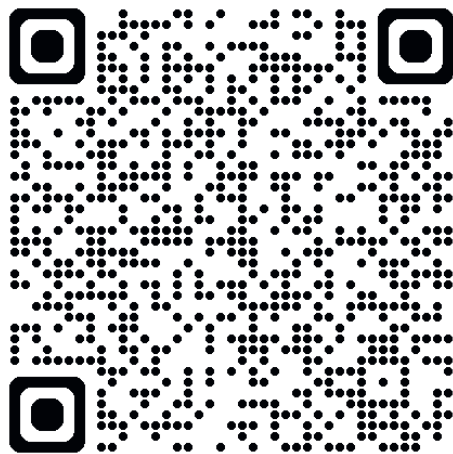
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Supplementary file (appendices)

The supplementary file can be downloaded using the QR code below.





CHAPTER

8

Prognostic factors for return to work following knee arthroplasty (Review)

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Abstract

Background - An increasing proportion of people receiving knee arthroplasty are of working age, making return to work a key participation outcome. Despite generally favorable clinical outcomes, many patients experience delayed or incomplete return to work. Knowledge of prognostic factors may help clinicians manage expectations, support shared decision-making, and guide work-integrated care.

Objectives - To examine the association between four preoperative prognostic factors—physical work demands, type of arthroplasty (unicondylar knee arthroplasty (UKA) or total knee arthroplasty (TKA)), duration of preoperative sick leave, and patients' expectations regarding recovery—and return to work following primary knee arthroplasty.

Search methods - We searched CENTRAL, MEDLINE, Embase, ClinicalTrials.gov, the WHO International Clinical Trials Registry Platform, and the EU Clinical Trials Register from inception to 4 October 2021, and updated the search on 9 December 2024. Reference lists and forward citation tracking were used to identify additional eligible studies.

Selection criteria - We included prospective and retrospective cohort studies and prognostic studies nested within randomized trials involving adults in paid employment receiving primary total or unicompartmental knee arthroplasty for osteoarthritis, reporting associations between at least one prespecified prognostic factor and return to work outcomes, preferably defined as initial and full return to work.

Data collection and analysis - Two authors independently screened studies, extracted data, and assessed risk of bias using the QUIPS tool. We synthesized time-to-event outcomes using hazard ratios (HRs) and dichotomous return to work outcomes using risk ratios (RRs), applying random-effects meta-analyses with Hartung–Knapp adjustment where appropriate. Certainty of evidence was assessed using GRADE.

Main results - We included 22 studies ($n = 6,798$ participants). Overall return to work rates were 74% within 6 months and 82% beyond 6 months after surgery. The pooled median and mean time to return to work were

both 90 days (95% CI: 87-93, IQR: 60-150). Higher physical work demands (Hazard Ratio (HR) = 0.5, 95% CI 0.3-0.8) were associated with slower time to return to work, however not with the proportion of patients returning to work. UKA was significantly associated with a higher proportion of patients returning to work (RR = 1.9, 95%CI 1.4-5.6), whereas type of arthroplasty was not significantly associated with the time to return to work. Preoperative sick leave and patients' expectations regarding recovery were not significantly associated with the proportion of patients returning to work. The methodological quality of the included studies varied considerably, with a majority demonstrating multiple domains at high risk. Most certainty of evidence was graded low or very low according to GRADE due to risk of bias, heterogeneity, and imprecise outcome definitions for prognostic factors and return to work.

Authors' conclusions - Return to work after knee arthroplasty is influenced by multiple interacting clinical, occupational, and personal factors rather than single patient or surgical characteristics. Preoperative sick leave and patients' expectations appear most relevant for time to return to work, but evidence remains uncertain. Standardized return to work definitions and better-designed prognostic studies are needed to better support work-integrated care, including the four prognostic factors investigated in this study.

Funding and registration - This review was made possible through funding of Amsterdam Public Health research institute. Cochrane Database of Systematic Reviews, Protocol published 2024, Art. No.: CD015272.

Plain language summary

Prognostic factors for return to work following knee arthroplasty

How did we do the review?

We searched major medical databases and trial registries up to 4 October 2021, and updated the search on 9 December 2024. We included studies of adults who had paid work before surgery and had primary unicondylar knee arthroplasty (UKA) or total knee arthroplasty (TKA) for osteoarthritis. Two reviewers independently selected studies, extracted data, and assessed risk of bias.

What did we find?

We included 22 studies with 6,798 participants.

Overall return to work rates

About 74% of people returned to work within 6 months after surgery.

About 82% returned to work after 6 months (up to 36 months).

Across studies, the average time to return to work was 90 days (roughly 3 months), but this varied a lot between studies and countries.

What do the results mean for the four prognostic factors?

1. Physical work demands: Results were inconsistent. Some studies suggested physically demanding work delays return, others found no difference, and measures of “work demands” differed a lot between studies. Overall: no consistent association.
2. Type of arthroplasty (UKA vs TKA): Some studies suggested people with UKA return sooner than those with TKA, but results were not consistent across different follow-up periods and outcome types. Overall: no consistent association.
3. Preoperative sick leave: People who had longer sick leave before surgery tended to return to work more slowly (based on time-to-return analyses). When studies only looked at whether people had returned by a certain time point (yes/no proportions), results were unclear. Overall: probably relevant for how fast people return, but confidence in the size of the effect is limited.
4. Patients’ expectations regarding recovery: People with more favorable expectations (expecting a quicker recovery/return) often returned to work earlier in studies that looked at time to return.

Results were unclear in studies that only reported yes/no return to work proportions. Overall: likely relevant for time to return, but evidence is uncertain.

How certain are we about these findings?

The certainty of the evidence was low to very low for most findings. This is mainly because:

Studies used different definitions of “return to work” (some measured first/partial return, some full return, many did not clearly define it). Follow-up times varied widely. Many studies did not adequately adjust for important factors (for example job flexibility, workplace accommodations, or prior work absence). Some results were imprecise or inconsistent across studies.

What are the key take-home messages?

- Return to work after knee arthroplasty is influenced by a combination of clinical, work-related and personal factors, and results vary between studies.
- Preoperative sick leave and patients’ expectations regarding recovery seem most relevant for how quickly people return to work, but the evidence is uncertain.
- For physical work demands and type of arthroplasty, the evidence does not show a consistent link with return to work.
- Future research should use standardized return to work definitions (clearly distinguishing initial and full return), the prognostic factors and the way they are measured. This should result in better-designed studies to clarify which factors matter most.

Funding and registration

This review was made possible through funding of Amsterdam Public Health research institute and was registered in the Cochrane Database of Systematic Reviews (protocol: CD015272).

Summary of findings

Summary of findings: Physical work demands

Prognostic factor	Outcome (definition & timing)	Association	Participants (studies)	Certainty of evidence (GRADE)	Key limitations / comments
Physically demanding work (heavy vs light)	Time to return to work	No consistent association	~900 (3 studies)	⊗○○○ Very low	Mixed and opposing results; heterogeneous exposure definitions
Physically demanding work (heavy vs light)	Proportion return to work ≤ 6 months	No clear association	~3,000 (12 studies)	⊗○○○ Very low	Effect estimates around null; high risk of bias in covariates
Physically demanding work (heavy vs light)	Proportion return to work > 6 months	No clear association	~1,100 (4 studies)	⊗○○○ Very low	return to work frequently undefined or combined categories

Summary of findings: Type of arthroplasty (UKA vs TKA)

Prognostic factor	Outcome (definition & timing)	Association	Participants (studies)	Certainty of evidence (GRADE)	Key limitations / comments
Type of arthroplasty (UKA vs TKA)	Time to return to work (any return to work definition)	No significant association (Figure 8)	~1,200 (3 studies)	⊗⊗○○ Low	Time-to-event estimates inconsistent; limited adjustment for work-related confounders. Pooled mean difference was not statistically significant associated to time to return to work.
Type of arthroplasty (UKA vs TKA)	Proportion return to work ≤ 6 months (any return to work definition)	No significant association (Figure 9)	~1,500 (5 studies)	⊗⊗○○ Low	Overall pooled estimate favoured UKA, but short-term stratified analyses crossed the 0. Note: when not stratified for short and long term, UKA was associated with a higher proportion of patients returning to work.
Type of arthroplasty (UKA vs TKA)	Proportion return to work > 6 months (any return to work definition)	No significant association (Figure 9)	~900 (3 studies)	⊗⊗○○ Low	Few long-term data; return to work often undefined (initial vs full return to work not distinguished). Note: when not stratified for short and long term, UKA was associated with a higher proportion of patients returning to work.

Summary of findings: Preoperative sick leave

Prognostic factor	Outcome (definition & timing)	Association	Participants (studies)	Certainty of evidence (GRADE)	Key limitations / comments
Preoperative sick leave (long vs short)	Time to return to work	Data could not be pooled	~2,100 (2 studies)	⊗⊗○○ Low	Data could not be pooled due to heterogeneity in outcomes.
Preoperative sick leave (long vs short)	Proportion return to work ≤ 6 months	No clear association (RR 2.27, 95% CI 0.96–5.35)	~1,200 (5 studies)	⊗⊗○○ Low	Very high heterogeneity ($I^2 \approx 94\%$); wide confidence interval
Preoperative sick leave (long vs short)	Proportion return to work > 6 months	-	0 studies	-	No studies were included.

Summary of findings: Expectations regarding recovery / return to work

Prognostic factor	Outcome (definition & timing)	Association	Participants (studies)	Certainty of evidence (GRADE)	Key limitations / comments
Positive expectations	Time to return to work	Data could not be pooled	~1,400 (3 studies)	⊗⊗○○ Low	Expectation constructs and measurements heterogeneous. Data could not be pooled due to heterogeneity in outcomes and operationalization of the prognostic factor.
Positive expectations	Proportion return to work ≤ 6 months	Data could not be pooled	~900 (2 studies)	⊗○○○ Very low	Binary outcomes underpowered. Data could not be pooled due to heterogeneity in outcomes and operationalization of the prognostic factor.
Positive expectations	Proportion return to work > 6 months	Data could not be pooled	~600 (1 study)	⊗○○○ Very low	Single study; indirect return to work definition.

Background

Knee replacement surgery or knee arthroplasty is the preferred treatment for people with end-stage knee osteoarthritis. Over the coming decades, there will be a steep rise in demand from people seeking knee replacement surgery. For instance, in Australia, an increase of 276% is expected (2013 to 2030); in the Netherlands, the increase is expected to be 297% (2005 to 2030).¹ The largest increase in knee arthroplasty is expected amongst people of working age.² This could be due to the good clinical outcomes of knee arthroplasty, the obesity

epidemic, and the rising pension age.² In several countries, the proportion of people under 65 years who had knee arthroplasty is already substantial, i.e. 30% to 40%.^{1,3-8}

Description of the health condition and context

For young people having knee arthroplasty, who are most often still active at work and in their social activities, societal participation is of the utmost importance, and returning to work after knee arthroplasty is likely the most important participation goal for many.⁹ Since most people consider work a source of social capital and social support, societal participation and return to work after knee arthroplasty are important predictors of a good quality of life.⁹

However, despite the good clinical outcomes of pain relief and improved knee function after knee arthroplasty, recent studies show that return to work outcomes are poor. About 40% of people with preoperative employment who have had knee arthroplasty do not return to work within six months, and one third do not return to work at all.¹⁰ The current standard postoperative care after knee arthroplasty is not targeted towards work participation.¹¹⁻¹⁶ Usual care for people eligible for knee arthroplasty is typically limited to the surgical placement of an implant. It may be supplemented with:

- a presurgical evaluation by the surgeon, physician assistant, or both;
- pharmaceutical treatment, such as anti-inflammatory, antibacterial, or pain relief medication;
- postsurgical clinical check-ups, mainly targeted at implant position, wound healing and joint function;
- depending on the individual's insurance, physical therapy to regain functional recovery and optimal joint mobility.

Consequently, the current usual care includes no evidence-based clinical pathway for return to work after knee arthroplasty. Clinicians lack the training, awareness, and disease-specific evidence in clinical guidelines to enable them to assist in guiding return to work after knee arthroplasty. Knowledge of the prognostic factors that influence return to work might help to manage patients' expectations, enhance shared decision-making, and improve multidisciplinary work-integrated care by healthcare professionals who provide rehabilitation.

Therefore, we conducted this current systematic review to identify prognostic factors for return to work after knee arthroplasty, as described in the peer-reviewed medical literature. This information is useful in clinical practice. As an example, Pahlplatz and colleagues examined participants' perspectives on

barriers and facilitators for return to work after total knee arthroplasty. They concluded that incorporating return to work as an explicit objective within the clinical pathway may facilitate more individualized, work-oriented rehabilitation, with adjustments throughout recovery to prevent unnecessary delays in return to work.¹⁶

In this review, we aim to explore four prognostic factors, including the strength of these factors, for return to work after knee arthroplasty: physical work demands, type of arthroplasty, sick leave before surgery, and patient expectations regarding recovery. We chose these four because these factors were recurring as possible prognostic factors in recent systematic reviews.¹⁷⁻¹⁹ We categorized the prognostic factors according to the International Classification of Functioning, Disability and Health (ICF) framework, enabling a theoretically grounded interpretation of how biomedical, work-related, and psychosocial components interact in shaping return to work outcomes. We hope our results will add knowledge towards clinically-relevant prognostic factors that can be used to manage patient expectations, enhance shared decision-making, and improve timely, multidisciplinary, work-integrated care. For instance, on an individual level, a patient can be informed about the likelihood of returning to work, and the factors that might enhance or hinder this return to work. Realistic work-related therapy goals can then be discussed and set. People at risk of a delayed return to work might receive additional work-integrated care, for example, a timely referral to an occupational or physical medicine and rehabilitation physician, as indicated. Prognostic factors for return to work can also be used at a population level, by incorporating this information into guidelines for knee arthroplasty vocational rehabilitation.

Why it is important to do this review

There has been a substantial increase in knee arthroplasty amongst the working-age population. Systematic reviews found a wide range in the time it took different people to return to work, indicating that prognostic factors play an important role to facilitate return to work.¹⁷⁻¹⁹ In order to narrow this range, more attention should be given to the prognostic factors involved. Appropriate advice, care, and guidance can be aimed at modifiable prognostic factors, such as patients' expectations for recovery, to improve timely work participation.

A recent systematic review identified a number of prognostic factors affecting return to work after total knee arthroplasty: physical nature of employment, preoperative absence from work, flexible work conditions, older age, being self-employed, age less than 45 years in a military population, level of education, functional outcome of total knee arthroplasty, change in Knee Osteoarthritis

Outcome Score (KOOS) sport subscale score from baseline, good self-rated health.¹⁹

Our review will expand upon the following items in contrast to a previous systematic review¹⁹

- We will differentiate between nine return to work outcomes (yes/no in the short- and long-term and the time to return to work. For first, full and undefined return to work) and report those separately.
- Due to the recurrence of the three prognostic factors: physical work demands, preoperative sick leave and patients' expectations, we will include these in our search.²⁰⁻²²
- Due to the increasing prevalence of people with unicompartmental knee arthroplasty, especially in the working-age population, we will expand the search to include unicompartmental knee arthroplasty.²
- We will not include systematic reviews or qualitative studies. However, we will check the references of systematic reviews and qualitative studies identified during our search for potential relevant articles.
- We will undertake a more comprehensive search, based on a validation set of references, to capture eligible studies they failed to include. See our preliminary study selection in [Supplementary material 5](#).
- If possible, we will perform a meta-analysis to calculate reliable and valid estimates of the strength of similar prognostic factors.

Objectives

We will examine four prognostic factors for return to work that can be used to manage patient expectations, enhance shared decision-making, and improve timely, multidisciplinary, work-integrated care. These are: physical work demands, type of arthroplasty, preoperative sick leave and patients' expectations.

The research question

Which of the following four prognostic factors, categorized according to the International Classification of Functioning, Disability and Health (ICF) framework, are associated with return to work after primary knee arthroplasty in patients with a paid job: physically demanding work (environmental factors), type of arthroplasty (health condition), sick leave before surgery (participation) and patient expectations regarding return to work (personal factors)?

PICOTS

We define our PICOTS as:²³

- Patients (P): individuals engaged in paid employment who actively choose primary total knee arthroplasty or unicompartmental knee arthroplasty as a treatment option for knee osteoarthritis.
- Index prognostic factors (I): we will consider these prognostic factors.
 - Engagement in physically demanding work
 - Type of arthroplasty
 - Duration of sick leave prior to surgery
 - Person's expectations regarding recovery
- Comparator (C):
 - Engagement in physically demanding work: light versus medium and heavy knee-demanding work
 - Type of arthroplasty: unicompartmental knee arthroplasty versus total knee arthroplasty
 - Duration of sick leave prior to surgery: short-term versus long-term
 - Patient expectations regarding recovery: positive versus negative
- Outcomes (O): the primary outcome is the return to work, which is further classified by:
 - Nature of return to work: initial, full, or undefined;
 - Method of measurement:
 - Dichotomous (yes/no): short- and long-term return to work;
 - Scale: duration of return to work.
- Time (T): prognostic factors will be assessed preoperatively. The outcome, i.e. return to work, is measured as dichotomous data (short- and long-term) and on a scale.
 - Short-term (≤ 6 months post-surgery)
 - Long-term (> 6 months but not exceeding 36 months post-surgery)
 - Duration until return to work
- Setting (S): range of hospitals and clinics, social security and healthcare systems from multiple countries

Methods

Description of the prognostic factors

We assessed four prognostic factors for return to work amongst people after knee arthroplasty, including an evaluation of the strength of the association, based on previous reviews.¹⁷⁻¹⁹ We categorized them according to the World Health Organization's International Classification of Functioning, Disability and Health

(WHO-ICF). Our hypothesis was that outcomes marked with (+) are prognostic factors that positively influence return to work.

- Environmental factors: physically demanding work (light (+) versus medium and heavy knee-demanding work)
- Health condition: type of arthroplasty (unicompartmental knee arthroplasty (+) versus total knee arthroplasty)
- Participation: sick leave before surgery (short-term (+) versus long-term)
- Personal factors: patient expectations regarding recovery (positive (+) versus negative)

Health outcomes

The primary outcome of interest was return to work following knee arthroplasty. The definition of the outcome was based on the nature of the return and the method of measurement.

Status of return to work

- Initial return to work: partial resumption of work
- Full return: complete resumption of work
- Undefined: status of return to work, initial or full, is not defined

Method of measuring return to work

- Longitudinal: duration of time from surgery to return to work
- Dichotomous:
 - Short-term: return to work within a period of six months post-surgery
 - Long-term: return to work after a period exceeding 6 months but not exceeding 36 months post-surgery

Considering these categorisations, we could identify nine distinct outcomes, which are tabulated as follows

	Duration of return	Short-term return	Long-term return
Initial return to work			
Full return to work			
Undefined return to work			

We focused on (societal) participation in this review. We defined “work” as any form of paid employment, regardless of the number of hours worked. We defined return to work as resuming the primary job (i.e. the same job held prior to the surgery), transitioning to a modified job, or taking a new job altogether.

Criteria for considering studies for this review

We reported the study selection process in a PRISMA flowchart.²⁴ We provided details according to the Prognosis Research Strategy (PROGRESS) framework.²⁵

Studies must be published as peer-reviewed research articles, in a peer-reviewed journal, and the full text of the article must be available.

Types of studies

We included cohort studies, both prospective and retrospective, and prognosis studies based on randomized controlled trials (RCT). There were no language restrictions.

Targeted population

We included studies with participants who had a paid job prior to surgery, and who received a primary total or unicompartmental knee arthroplasty due to knee osteoarthritis.

We included trials with a mixed population (e.g. osteoarthritis and trauma) if at least 70% of the participants had osteoarthritis as the indication for knee arthroplasty. If the data were presented separately for different indications, we only included data from participants with knee osteoarthritis. If an indication for knee arthroplasty was not mentioned for the included participants in a study, we included those papers, as we assumed that osteoarthritis was the main indication for the majority of the participants.

We excluded studies that reported data on participants who were unemployed preoperatively, on participants who received a second or revision knee arthroplasty, or on participants who received other types of surgery.

Types of prognostic/predictive factor(s) or model(s)

The review assessed four prognostic factors described in the literature for return to work after knee arthroplasty, categorized according to the WHO-ICF: physically demanding work, type of arthroplasty, sick leave before surgery and patient expectations regarding recovery.

Types of outcomes to be predicted

Our return to work outcomes were operationalized as either longitudinal (time to return to work) or dichotomous (short- and long-term return to work) measures. For each outcome, we classified return to work as initial or full return to work, or as undefined when this distinction was not explicitly reported.

Effect measures of the outcome, return to work, could be expressed as hazard ratios (HR), odds ratios (OR), risk ratios (RR), percentages, and mean or median differences, with measures of variation, such as standard deviation, interquartile range, or range (minimum to maximum). Return to work was calculated for short- (within 6 months) and long-term postoperative time periods (exceeding 6 months but not exceeding 36 months postoperative).

Search methods for identification of studies

Our search methods for identification of studies were specified below.

Electronic searches

Based on a validation set of references, and with the support of a clinical librarian, we searched the following databases and trial registers. Our search strategies are listed in Supplementary material 1.

Cochrane Central Register of Controlled Trials (CENTRAL; current issue) in the Cochrane Library

- MEDLINE Ovid (1946 to search date)
- Embase Ovid (1974 to search date)
- US National Institutes of Health Ongoing Trials Register ClinicalTrials.gov (www.clinicaltrials.gov)
- World Health Organization International Clinical Trials Registry Platform (apps.who.int/trialsearch)
- EU Clinical Trials Register (www.clinicaltrialsregister.eu)

Searching other resources

We snowballed our search (screened all the articles that cited our included papers), checked the reference list of all included articles, and conducted a forward citation search using Web of Science to identify studies missed from the original electronic searches.

Data collection

Selection of studies

Two review authors independently screened all titles and abstracts using Rayyan.²⁶ DOS, ACS, and PPFMK assessed one third of the titles and abstracts each, and the other nine co-authors assessed one ninth each. If there was a disagreement between the review authors during screening of the titles and abstracts, they discussed to reach consensus. When consensus could not be reached, a review author not originally assigned to that article was consulted for a final decision.

Review of the full-text articles was completed by the same pair of review authors who reviewed the title and abstract.

We excluded papers that did not examine the effect of at least one of the four prognostic factors. We gave reasons for exclusion at the full-text stage, and presented them in a characteristics of excluded studies table. We completed a PRISMA flowchart that included the numbers of articles identified, included, and excluded.

Data extraction

We extracted the following characteristics from the included studies ([Supplementary material 6](#)).²⁷

- Source of data: study design (prospective/retrospective)
- Participants : inclusion and exclusion criteria of the study, participant characteristics (age, sex, year of arthroplasty, comorbidity, level of education)
- Outcomes to be predicted: how return to work was defined (initial, full, or undefined), measured (dichotomous/longitudinal), assessed (self-report measures versus register-based), and the corresponding return to work outcomes; number of participants resuming their primary job (i.e. the same job held prior to the surgery), transitioning to a modified job, or taking up a new job altogether; more or less working hours compared to pre-surgery
- Prognostic factors: physically demanding work, type of arthroplasty, sick leave before surgery and patient expectations regarding recovery
- Sample size: number of included participants, availability of sample size calculation
- Missing data: number of participants lost to follow-up
- Analysis: modeling methods
- Results: unadjusted and adjusted prognostic effect estimates. If multiple adjusted models are reported, we included the fully adjusted model in our analysis.
- Interpretation and discussion (interpretation of present results)

The CHARMS-PF checklist was the starting point for our data extraction form, to which we added other relevant items ([Supplementary material 6](#)).²⁸ Two of three review authors (DOS, ACS, and PPFMK) independently extracted the data and compared results. If discrepancies arose during this discussion that could not be resolved, the third review author was consulted for a final decision. We pilot tested the data extraction form in two studies beforehand. If deemed

necessary, we contacted study authors to obtain missing data or confirm unclear information to enhance precision and reduce the impact of reporting biases. Missing information could be for instance definition of prognostic factor or return to work outcome, or study results.

For studies authored by members of the review team, data extraction was performed by review authors who were not involved in the conduct or reporting of that study. Any disagreements were resolved by a third reviewer who also had no authorship involvement in the study under consideration.

Assessment of risk of bias in included studies

Two review authors independently assessed the risk of bias for each included study and for each prognostic factor (two of the three review authors (DOS, ACS, PPFMK) using the Quality In Prognosis Studies (QUIPS) tool ([Supplementary material 7](#)).²⁹ Disagreement was resolved by the two review authors who assessed the study. In the case of disagreement, a third review author was consulted. We pilot tested the risk of bias assessment in two studies beforehand.

The QUIPS tool considers six domains: study participation, study attrition, prognostic factor measurement, outcome measurement, study covariates, and statistical analysis and reporting.²⁹ We added 'competing risks' to our risk of bias assessment. If competing risks were not reported or measured, we assessed the report as having a higher risk of bias. We extracted relevant information from the study and noted methodological considerations relevant to each domain. We judged each domain and each prognostic factor as high, moderate, or low risk of bias.²⁹

For studies authored by members of the review team, risk of bias assessment was performed by review authors who were not involved in the conduct or reporting of that study. Any disagreements were resolved by a third reviewer who also had no authorship involvement in the study under consideration.

Measures of association or predictive performance measures to be extracted
For dichotomous outcomes, we extracted the number and percentage of those returning to work in the short-term and long-term. For longitudinal outcomes, we extracted the mean, median, standard deviation, interquartile range, and range.

We extracted these measures of association.²⁷

- Odds ratio (OR) or risk ratio (RR) from univariable or univariate models between the prognostic factor and the outcome, return to work (short-

or long-term), with 95% confidence interval (CI), or standard error (SE). If available, we extracted the actual number and percentage of participants who reported the prognostic factor, and returned to work.

- Hazard ratio (HR) from univariate or univariable models between prognostic factor and the outcome, time-to-return to work, with 95% CI or SE
- Adjusted OR or RR between the prognostic factor and the outcome, return to work (short- or long-term), with 95% CI or SE. If multiple adjusted ORs or RRs were reported, we extracted all of them.
- Adjusted HR between the prognostic factor and the outcome, time-to-return to work, with 95% CI or SE. If multiple adjusted HRs are reported, we extracted all of them.

For our dichotomous (short- and long-term) outcome, our preferred summary estimate was the RR. In line with the Cochrane handbook, if RR was not mentioned, we tried to convert OR to RR (as described in details below). We also calculated RR from percentages. For the outcome 'time-to-return to work', our preferred summary estimate is the HR. If the data did not allow to calculate the HR or RR, and if we were unable to obtain the data from the study authors, we excluded the study for pooling analysis with reason.

Dealing with missing data

If data were missing, we contacted the corresponding study author. If authors were unresponsive, we noted this in our review. We included this in our risk of bias assessment, and excluded the study with reason if we were unable to proceed with our analyses.

Assessment of heterogeneity

We examined clinical heterogeneity and statistical diversity amongst the included studies, since this may affect the overall prognosis. We assessed heterogeneity by calculating the I^2 statistic. We visually inspected the forest plots, looking for overlap of point estimates and 95% CIs. We explored the possible sources of heterogeneity through subgroup analysis.

Assessment of reporting deficiencies

We conducted the review according to our published protocol [74], and reported any deviations from it in the differences between protocol and review section. To assess publication bias, we visually examined asymmetry in funnel plots if we included at least 10 studies per prognostic factor.

Data synthesis

Data synthesis and meta-analysis approaches

We pooled the measures of association with meta-analyses, preferably using Review Manager's generic inverse variance methods random-effects model [6]. When feasible, we applied a Hartung–Knapp adjustment for random-effects meta-analyses to better account for uncertainty when the number of included studies was small. We reported a separate meta-analysis for each type of association (i.e. unadjusted and adjusted), and for each outcome per prognostic factor. We presented the results of the meta-analyses in forest plots for each comparison.

As previously mentioned, our preferred summary estimate was the RR for dichotomous outcomes (short- and long-term return to work), and the HR for longitudinal outcomes (time-to-return to work). For dichotomous outcomes, we preferentially defined the event as *not returned to work* (no return to work) to ensure consistent interpretation across studies. Where studies reported return to work (yes) as the event, we recoded effect estimates to match this prespecified event definition by inversion.

If RRs were not reported, we derived RRs from reported 2×2 tables or from percentages. When only ORs were available, we re-expressed ORs as RRs using the Cochrane-recommended approach, applying the baseline risk in the comparator group (P0) as the reference risk. If a study contained a zero cell in a 2×2 table, we applied a continuity correction (e.g. Haldane-Anscombe) to enable estimation of RRs and corresponding standard errors.

For time-to-event outcomes, we harmonised the direction of effect to ensure consistent interpretation across studies. If required, we inverted hazard ratios so that $HR > 1$ consistently indicates a slower return to work associated with exposure to the prognostic factor, and we transformed confidence intervals accordingly.

In addition to relative measures of association, we summarised absolute return to work proportions across studies at prespecified follow-up windows (≤ 6 months and > 6 to 36 months), and by return to work status (initial, full, or undefined). Where appropriate, we performed random-effects meta-analyses of proportions to estimate pooled return to work rates with 95% confidence intervals.

We conducted separate syntheses by (1) return to work status (initial, full, undefined) and (2) follow-up window (short-term ≤ 6 months; long-term > 6 to 36 months), in line with our predefined outcome classification. Where random-

effects meta-analyses were performed, we reported 95% prediction interval when feasible to reflect the expected range of effects in comparable future settings.³⁰

Subgroup analysis and investigation of heterogeneity

We undertook subgroup analyses for risk of bias (low versus moderate and high), willingness to return to work, and care provided besides knee arthroplasty (e.g. additional pre- or postoperative rehabilitation) for the four prognostic factors. Effect estimates derived from studies at low risk of bias provided the most credible approximation of the true association between the prognostic factor and return to work. We presumed that willingness to return to work and additional rehabilitation would enhance return to work outcomes.

Sensitivity analysis

We undertook a sensitivity analysis for the definition of three of the four prognostic factors: physically demanding work, sick leave before surgery and patient expectations regarding recovery.

We did not undertake a sensitivity analysis for the type of surgery besides UKA and TKA (i.e. robotic surgery versus nonrobotic surgery), since we were of the opinion that the quality of the procedure and prosthesis implant were similar for unicompartmental knee arthroplasty and for total knee arthroplasty regarding work participation. Therefore, we considered all participants with unicompartmental knee arthroplasty similar; the same goes for participants with total knee arthroplasty.

Conclusions and summary of findings

We described the prognostic factors and the strength of association for return to work after knee arthroplasty, categorized according to the WHO-ICF. We created a Directed Acyclic Graph model to visualise the relation between the prognostic factors and return to work, if the certainty regarding the effect estimates allow.³⁰

GRADE

We used the GRADE framework to assess the overall certainty of evidence for prognostic factors for return to work after knee arthroplasty.³¹

- High: we are very confident that the variation in risk associated with the prognostic factor (probability of future events in those with/without the prognostic factor) lies close to that of the estimate.
- Moderate: we are moderately confident that the variation in risk associated with the prognostic factor (probability of future events in those with/without the prognostic factor) is likely to be close to the estimate, but there is a possibility that it is substantially different.

- Low: our certainty in the estimate is limited; the variation in risk associated with the prognostic factor (probability of future events in those with/without the prognostic factor) may be substantially different from the estimate.
- Very low: we have very little certainty in the estimate; the variation in risk associated with the prognostic factor (probability of future events in those with/without the prognostic factor) is likely to be substantially different from the estimate.

Prospective observational studies

Prospective observational studies provide high-quality evidence for prognostic factors, and therefore, we started with high certainty.³¹ The certainty will be downgraded by one level for risk of bias, inconsistency, imprecision, indirectness, and publication bias.³¹⁻³⁴

- Risk of bias: the certainty of a prognostic factor is downgraded if most evidence is from studies with a moderate or high risk of bias for most of the QUIPS domains: study participation, study attrition, outcome measurement, study covariates, and statistical analysis and reporting.
- Inconsistency: the certainty of a prognostic factor is downgraded based on variability in point estimates using 95% CIs, extent of overlap of these intervals, large I^2 , and where point estimates lie in relation to clinically meaningful differences for return to work. We consider a 5% increase in return to work, and a return to work of seven working days earlier to be clinically relevant, based on consensus and in line protocol paper.³⁵ We prespecified subgroup analysis, and will investigate heterogeneity to explore differences across categories. See Subgroup analysis and investigation of heterogeneity.
- Imprecision: the certainty of a prognostic factor is downgraded if the range of the 95% CI for a risk estimate is > 2.0 , or the lower bound of the 95% CI is not seen as a clinically meaningful difference for return to work.
- Indirectness: the certainty of a prognostic factor is downgraded if the prognostic factor is rated at high risk of bias for the QUIPS domain, prognostic factor measurement. We do not expect to downgrade for the selected population, because our inclusion criterion is people of working age with knee arthroplasty.
- Publication bias: the certainty of a prognostic factor is downgraded if publication bias is suspected, based on funnel plot representation, preferably supplemented with a Peters' test level or Egger's regression test.^{36,37}

Dose-response relationships

Certainty can be upgraded by one level for a large effect estimate and the presence of a dose-response relationship:

- Large effect estimate: the certainty of a prognostic factor is upgraded if a risk estimate is > 2.5 and the 95% CI is < 2 of a risk estimate, or a clinically meaningful large difference in the return to work outcome.
- Presence of dose-response relationship: the certainty of a prognostic factor is upgraded if the study reports an established dose-response relationship.

Two review authors independently graded the evidence and resolved differences by discussion, or by involving a third review author. We constructed a summary of findings table for each prognostic factor, to present our certainty of the evidence.

Differences between protocol and review

The review was conducted in accordance with the published protocol, with five deviations.³⁵ First, the search was updated to 9 December 2024 to ensure inclusion of the most recent evidence. Second, for dichotomous outcomes, we harmonised the event definition by defining the event as “no return to work”; where studies reported return to work as the event, effect estimates were inverted to ensure consistent interpretation and hazard ratios were similarly harmonised so that $HR > 1$ consistently indicated slower return to work associated with exposure. Third, we conducted random-effects meta-analyses of absolute return to work proportions at prespecified follow-up windows alongside pooling of relative effect measures (RRs and HRs). Fourth, to mitigate potential bias related to author overlap, studies co-authored by members of the review team were assessed for risk of bias and data extraction by review authors without authorship involvement in the respective study, with disagreements resolved by a third reviewer who was also not involved in that study. Finally, we performed additional exploratory subgroup analyses, including stratification by study design, to further investigate heterogeneity.

Results

Results of the search

The searches were conducted on October the 4th 2021 and updated our search on December the 9th 2024 (Figure 1). These searches yielded 7,700 records. Six thousand and sixty-five records were left after removing duplicates from which we excluded 6023 records based on title and abstract screening. We assessed 40 full-text reports for eligibility Figure 1. After excluding 18 articles^{20,38-54}, we included 22 studies in this review (Figure 1).^{21,22,55-74}

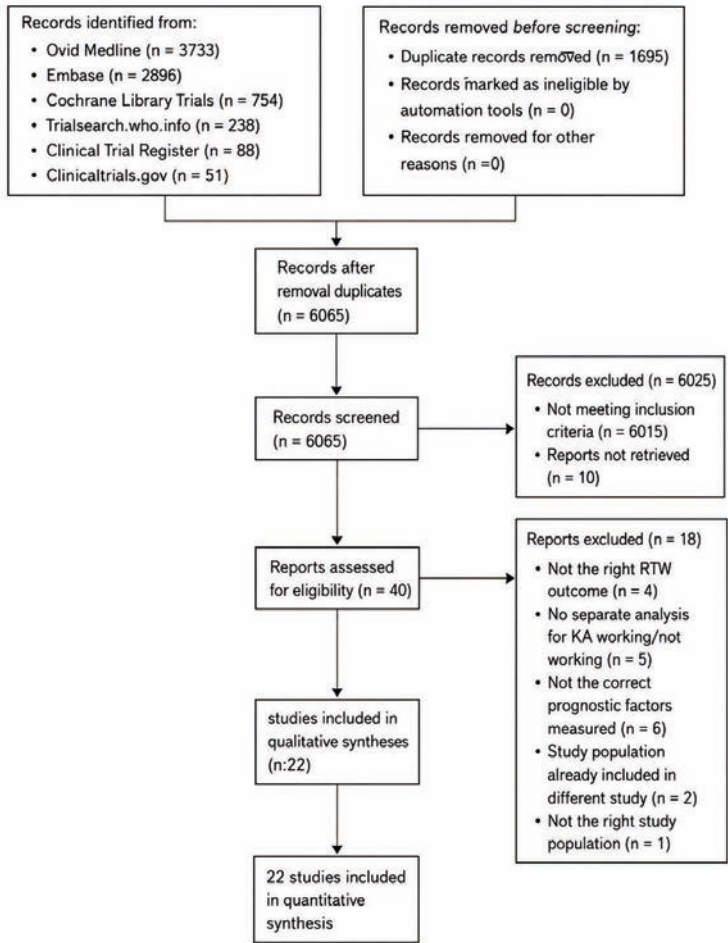


Figure 1: Flowchart

Included studies

Study designs

Ten included studies were prospective cohort studies^{22,55,58,60-62,64,65,71,72} (Table 1), whereas the remaining twelve were retrospective cohort studies. Two studies were register-based^{56,64} and eleven studies included patients from a single center (Table 1).^{55-57,59,65,66,68-71,73}

Table 1: characteristics of the included studies

Study	Study design	Data collection period	Centers (n)	Inclusion criteria	Exclusion criteria
Al-Hourani 2021	Prospective cohort study	Jan 2018-Nov 2018	Single center	Consecutive unilateral TKA in <65 y	Partial knee arthroplasty; bilateral TJA; revision TJA; already retired for non-joint reasons
Bei Na Tan 2024	Retrospective cohort study	Aug 2017-Mar 2020	Single center	Employed prior to surgery; medial compartment OA for UKA; tricompartmental OA for TKA	Not employed 6 months prior to surgery; bilateral knee arthroplasty; revision surgeries
Blevins 2020	Retrospective cohort study	2013-2015	Single center	Age 18-80 y; BMI 18-35; medial compartment OA; primary unilateral medial UKA or unilateral TKA; >=2 y follow-up; staged bilateral included if >=3 months apart	Inflammatory arthritis; previous ACL; other reconstructive surgery; revision surgery; implant removal; varus >10 deg
Boersma 2019	Prospective cohort study	Mar 2012-Jul 2016	Multicenter (4)	18-63 y with paid work; primary TKA for OA; Dutch language; consented	Unicompartmental KA; THA; TKA for secondary OA; revision arthroplasty
Footte 2010	Retrospective cohort study	2002-2006; Mar 2006-Jul 2006	Single center	Age <60 y and PFR; UKA or TKA at the study hospital	n.r.
Hoornje 2018	Prospective cohort study	Ongoing prospective longitudinal cohort	Multicenter (6)	<70 y; paid job pre-op; primary TKA for OA; able to complete questionnaires; Dutch literacy; informed consent	Rheumatoid arthritis; tumour; paresis; amputation; hemi-arthroplasty; revision TKA
Kamp 2023	Prospective cohort study	2012-2018	Multicenter (8)	Pre-operatively employed; 18-64 y; primary/secondary OA TKA; sufficient Dutch; informed consent	n.r.
Kangas 2024	Prospective cohort study	Oct 2020-May 2021	Multicenter (4)	Age 25-62; entitled to occupational health care; primary THA or total/unicompartmental knee arthroplasty for primary OA	n.r.
Kievit 2020	Retrospective cohort study	Jan 2003-Jan 2012	Multicenter (2)	Primary UKA or TKA in 2003-2012; alive at follow-up; in paid or voluntary work within 2 y pre-op; >=2 y post-op at survey	Deceased at follow-up
Kuijjer 2016	Retrospective cohort study	2005-2010	Multicenter (2)	Primary Vanguard TKA 2005-2010; in paid work <=2 y pre-op; >=2 y post-op follow-up	n.r.

Study	Study design	Data collection period	Centers (n)	Inclusion criteria	Exclusion criteria
Lankinen 2019	Prospective cohort study	1999-2011	Multicenter (16)	FPS cohort; single primary TKA and at least one FPS survey before surgery	n.r.
Leichtenberg 2016	Prospective cohort study	Oct 2010-Sep 2012	Single center	Paid workers <65 y with primary TKA for OA; Dutch literacy; able to complete questionnaires	Rheumatoid arthritis; tumour; paresis; amputation; hemi- or revision arthroplasty
Lombardi Jr. 2009	Retrospective matched cohort study	Jul 2004-Jul 2005	Single center	KA during study window met device-specific indications for UKA/TKA	n.r.
Lombardi Jr. 2014	Retrospective cohort study	Jul 2007-Jul 2010; interviews Aug 2011-Apr 2012	Multicenter (5)	Age 18-60 y; skeletally mature; primary TKA for non-inflammatory arthritis; surgery 1-3 y before study start; consent	Prior knee infection, sepsis, fracture, dislocation/revision of index knee; extensive comorbidities limiting activity
McGonagle 2019	Retrospective cohort study	2015-2017	Single center	Age <=65 y; unilateral primary TKA or medial UKA; surgery within previous 6-12 m; in paid work during 3 m pre-op	Revision hip/knee arthroplasty; bilateral concurrent hip/knee arthroplasty
Peters 2024	Retrospective cohort study	Aug 2019-Nov 2022	Single center	Primary TKA; ASA I-II; BMI <=35; informed consent; completed 3- and/or 6-month questionnaire	n.r.
Sankar 2013	Prospective cohort study	2005-2008	Multicenter (4)	Primary TKA for OA; age 18-85 y; English literacy; working or on short-term disability pre-surgery; informed consent	Revision/hemi-arthroplasty; arthroplasty for trauma/malignancy; not in labor force before surgery
Scheele 2024	Retrospective cohort study	1998-2011	Single center	Primary fully-cemented medial UKA or cruciate-retaining TKA; available for matched-pair selection	Non-cemented implants; prior surgery same knee; contralateral KA; other implant types
Scott 2017	Prospective cohort study	2010-2013	Single center	Consecutive primary TKA aged <=65 y	For bilateral cases the second knee only analyzed
Styron 2011	Prospective cohort study	n.r.	Multicenter (2)	Age 18-69 y; in paid employment; intending to return; primary TKA	Contralateral TKA <6 m before index surgery; prior HTO or UKR on index knee
Timmerman 2020	Retrospective cohort study	Patients operated Jan 2013-Dec 2017; study in 2018	Single center	Age <=62 y; employed pre-op; primary TKA for end-stage OA; bilateral first knee excluded	Age >62 y; within 3 y of retirement; secondary TKA; first knee of bilateral; not employed pre-op
Zaballa 2023	Retrospective cohort study	Mar 2010-Nov 2016; Jul 2017-Dec 2018	Multicenter (2)	UKA or TKA; age 18-65 y at surgery; >=5 y follow-up; consented to COAST study	n.r.

Study	Additional review-specific selection criteria	Sample size	% females	Age (SD)	BMI (SD)	Prognostic factors included
Al-Hourani 2021	THA cohort excluded; only TKA data extracted for knee-arthroplasty review	53	56%	Median 58 (IQR 56-62)	32.1 (6.0)	Physical work demands; expectations of recovery
Bei Na Tan 2024	n.a.	441 TKA, 69 UKA	TKA 67%; UKA 70%	67 (SD 7.7) TKA; 61 (SD 8.6) UKA	TKA 27.8 (SD 5.6); UKA 28.5 (SD 4.4)	Type of arthroplasty; sick leave; physical work demands
Blevins 2020	n.a.	286	44% TKA; 44% UKA	TKA 65.2 ± 9.0; UKA 62.6 ± 9.0	TKA 29.0 (SD 2.6); UKA 28.9 (SD 2.4)	Type of arthroplasty
Boersma 2019	Only TKA subgroup relevant (n=104)	146	56%	Median 56 (IQR 52-59)	29.9 (5.2)	Physical work demands
Footte 2010	TKA vs UKA subgroups extracted; PFR group not used in review	41 TKA, 31 UKA	TKA 46%; UKA 68%	TKA 54.1 (range 44-59)	n.r.	Type of arthroplasty
Hoorntje 2018	n.a.	266	56% (149/266)	58.3 (6)	29.6 (4.2)	Sick leave; physical work demands; expectations of recovery
Kamp 2023	TKA subgroup only; THA excluded; n=276 with complete occupation and RTW data	276	55% (151/276)	Median 58 (IQR 55-61)	Median 29 (IQR 26-32)	Physical work demands
Kangas 2024	Knee arthroplasty subgroup only (KJA=115); THA excluded	115	n.r.	n.r. (mean 56 [SD 5] whole cohort)	n.r.	Sick leave; physical work demands; expectations of recovery
Kievit 2020	n.a.	TKA 167, UKA 157	TKA 51%; UKA 49%	TKA 60.1 ± 8; UKA 60.0 ± 7	TKA 29.5 (SD 4.7); UKA 30.7 (SD 5.1)	Type of arthroplasty
Kuijter 2016	n.a.	167	51% (85/167)	60 ± 8	<30: 59%; ≥30: 42% (mean n.r.)	Sick leave; physical work demands
Lankinen 2019	n.a.	452	80% (362/452)	56.5 (5.1)	42.4% obese (BMI ≥30); mean BMI n.r.	Sick leave; physical work demands



Study	Additional review-specific selection criteria	Sample size	% females	Age (SD)	BMI (SD)	Prognostic factors included
Leichtenberg 2016	Only TKA with paid employment pre-operatively	56	55% (n=31)	56 (5.7)	30 (4.4)	Sick leave; physical work demands; expectations of recovery
Lombardi Jr. 2009	n.a.	206 (103 UKA, 103 TKA)	63% both groups	UKA 61 (SD 10); TKA 62 (SD 10)	UKA 31 + 5; TKA 31 + 5	Type of arthroplasty
Lombardi Jr. 2014	n.a.	661	61% (405/661)	54 (range 19-60)	n.r.	Physical work demands
McGonagle 2019	Only TKA and UKA	31 TKA, 27 UKA	52/116 (45%)	Overall respondents 56 +- 7.3; knee-only mean n.g.	n.r.	Type of arthroplasty; physical work demands
Peters 2024	n.a.	2,063	53%	Median 65.8 (IQR 7.2)	Median 27.8 (IQR 3.4)	Physical work demands
Sankar 2013	TKA subgroup only; hip replacements excluded	170	58% (98/170)	57.5 +- 7.2	Obese (BMI >=30): 42%; mean BMI n.r.	Physical work demands
Scheele 2024	n.a.	28 TKA, 28 UKA	TKA 57%; UKA 61%	At follow-up UKA 66.2 (SD 5.9); TKA 65.8 (SD 7.2)	UKA 28.6 (SD 6.2); TKA 29.0 (SD 6.2)	Type of arthroplasty
Scott 2017	n.a.	261	47%	59.6 (SD 4.8)	31.5 (SD 6.8)	Physical work demands
Styron 2011	n.a.	162	68.5% (111/162)	Median 57 (IQR 52-61)	Male 32.5 (6.3); female 36.8 (8.0)	Physical work demands; expectations of recovery
Timmerman 2020	n.a.	99	45% (45/99)	54.7 +- 5.5	29.3 (SD 5.2)	Sick leave; physical work demands
Zaballa 2023	n.a.	Total 251; TKA 108, UKA 143	57%	Median 60 (IQR 56-64)	51% obese (BMI >=30); 35% overweight; 13% normal	Type of arthroplasty

Study	Other prognostic factors measured but not included	Outcome definition	Outcome assessment	Follow-up period	Country
Al-Hourani 2021	Oxford Knee Score, EQ-5D, pain VAS, comorbidity count (not part of four predefined factors)	Return to work = any paid work (start return to work)	Self-completed employment questionnaire at baseline and 12 months	12 months post-surgery	Finland
Bei Na Tan 2024	Age, sex, ethnicity, paying class, BMI, ASA, chronic conditions, ambulation, pain in other joints, diagnosis codes, KSS/OKS, LOS, discharge location, full-time/part-time, waiting time	Return to work not defined	Register-based outcome from EMR/NHG REDCap: yes/no RTW and days to first paid work	Not reported	Singapore
Blevins 2020	None	n.r.	Post-operative patient questionnaire	Up to 2 years; RTW time recorded once per patient	United States
Boersma 2019	Pre-op total and leisure-time PA (SQUASH), age, sex, BMI, education, partner status, comorbidity count, WOMAC physical functioning	Days from surgery to first partial or full RTW	Self-reported questionnaires at 6 weeks, 3, 6 and 12 months	12 months	Netherlands
Foote 2010	Sex	Time from operation to RTW performing normal duties	Single retrospective postal questionnaire	Mean 36 months (range 14-61)	United Kingdom
Hoorntje 2018	Pre-op physical activity, sex, age, BMI, comorbidities, work adaptations, self-employment, KOOS, work-relatedness, sport participation, sport expectations	RTW at 12 m: full, partial or no RTW; median time-to-first RTW 3 m (IQR 2-5)	Self-administered questionnaires; telephone resolution of missing items	12 months	Netherlands
Kamp 2023	Sex, age, BMI, comorbidity count, HOOS-PS/KOOS-PS, self-employment	Days from surgery to first partial or full RTW	Self-administered questionnaires at 6 and 12 months; telephone follow-up	12 months	Netherlands
Kangas 2024	Age, sex, education, professional status, motivation, psychosocial load, underlying disease, Oxford/Knee scores incl pain	Days from surgery to first part- or full-time RTW	Self-reported date in follow-up questionnaire; censored at 12 months	12 months	Finland
Kievit 2020	Stopping-work interval, baseline workload, WORQ/WAI	Post-op RTW interval categorized (<=0-2 wk, 2-4 wk, 1-3 m, 3-6 m, >6 m)	One-off recall questionnaire	Cross-sectional survey >=24 months post-op (range 24-119)	Netherlands

Study	Other prognostic factors measured but not included	Outcome definition	Outcome assessment	Follow-up period	Country
Kuljer 2016	Sex, age, BMI, work-relatedness of symptoms, KOOS, ASA	RTW yes/no at survey; no RTW if patient ticked 'I didn't get back to work'	Single retrospective questionnaire completed in 2012	Mean 3.8 years (SD 1.3)	Netherlands
Lankinen 2019	Age, sex, marital status, obesity, smoking, alcohol, physical activity, comorbidities, psychological distress, self-rated health	Days from hospital discharge to end of medically certified sick leave within 1 year	Survey and national sickness absence register	Mean follow-up 4.3 years (SD 2.6)	Finland
Leichtenberg 2016	Self-employment, education, HOOS/KOOS/OKS, age, sex, work adaptations, living status, pre-op working hours	Full RTW classified as complete, partial, or no RTW	Self-reported questionnaire at 12 months	12 months	Netherlands
Lombardi Jr. 2009	Age, sex, BMI, ROM, alignment, Knee Society scores, activity scale	Weeks from surgery to resumption of work	Telephone or postal interview	Mean 31 months (range 1-52)	United States
Lombardi Jr. 2014	Sex, age, job restrictions, time since last work, implant type, etc.	Weeks unable to work after knee operation	Structured telephone interview	1-5 years post-TKA (mean 2.6 years)	United States
McGonagle 2019	Flexible work conditions quantitatively; qualitative factors incl recovery, motivation, necessity, flexibility, physical effects, limitations, restrictions	Resumption of paid employment at any capacity	Self-reported questionnaire	6-12 months post-op	Australia
Peters 2024	Age, sex, BMI, ASA, Charnley class, smoking, alcohol, operative time, complications, pain, KOOS-PS, EQ-5D-5L, OKS	Patient-reported resumption of low- or medium-impact paid work (yes/no)	Digital self-report questionnaires at 3 and 6 months	Up to 6 months after TKA	Netherlands
Sankar 2013	Job sector, age, sex, education, marital status, pre-op sick leave, WOMAC pain/function, Late-Life Disability Index, workplace limitations	First follow-up (1, 3, 6 or 12 m) reporting part-time or full-time paid employment	Postal self-report questionnaires	12 months	Canada
Scheele 2024	KOOS, UCLA activity, ROM, satisfaction, complications	RTW classified retrospectively into <6 weeks, 6-12 weeks, >12 weeks	Self-report	UKA 3.3 (SD 1.9); TKA 3.6 (SD 1.6)	Germany
Scott 2017	Age, sex, BMI, deprivation, comorbidities incl depression, UCLA, OKS, EQ-5D, pain VAS, WORQ, satisfaction, sick leave length, indication	Self-reported return to any paid job (same or different), full-time/part-time	Self-reported	Mean 3.4 years (2-4.9)	United Kingdom

Study	Other prognostic factors measured but not included	Outcome definition	Outcome assessment	Follow-up period	Country
Styron 2011	Age, sex, race, BMI, FCI, SF-12, self-employment, workplace accessibility, pain, insurance/compensation, motivation	Time to RTW to any amount of work and to full-time work; employment status at 3 months	Self-reported questionnaires pre-op, 4-6 wk, 3 m, 6 m	6 months	United States
Timmerman 2020	Age, sex, BMI, ASA, employment type, job adaptations, job satisfaction, education, Knee Society scores, prosthesis type, etiology	Able to resume work post-operatively? yes/no; time to RTW in weeks	Self-reported postal questionnaire + chart review	1-5 years post-op	Belgium
Zaballa 2023	Age at surgery, sex, BMI, time to best function, length of follow-up, procedure type	Ever returned to any paid employment after knee arthroplasty (yes/no)	Self-reported postal questionnaire ≥ 5 years post-op	Median 6.4 years (IQR 5.4-7.2)	United Kingdom

Country and time period

The included studies were conducted across ten countries. Most studies were performed in the Netherlands (n=7), the United States of America (n=4), Finland (n=3), and the United Kingdom (n=3) (Table 1). The studies spanned various time periods, with data collection occurring between 1998 and 2022 (Table 1). Several studies were conducted during the 2010s, representing the most common decade for data collection across the included research (Table 1).

Participants

Participant characteristics were predominantly homogeneous in age, sex, and BMI. Most cohorts enrolled patients in their mid-50s to early 60s (≈54–66 years) with mean BMIs around 30 kg/m² (typically 29–31), and in most studies more women than men were included (n≈17/22 reporting sex) (Table 1).

Sample sizes

The total number of participants in the included 22 studies was n = 6,798, ranging from 28⁷⁰ to 2,063⁶⁹ participants per study.

Prognostic factors

Across the 22 included studies, the four prespecified prognostic factors were extracted: physical work demands, type of arthroplasty, pre-operative sick leave, and expectations of recovery (Table 1). Physical work demands was the most frequently evaluated prognostic factor (16/22 studies), followed by type of arthroplasty (8/22), pre-operative sick leave (7/22), and expectations of recovery (5/22) (Table 1; Figure 4).

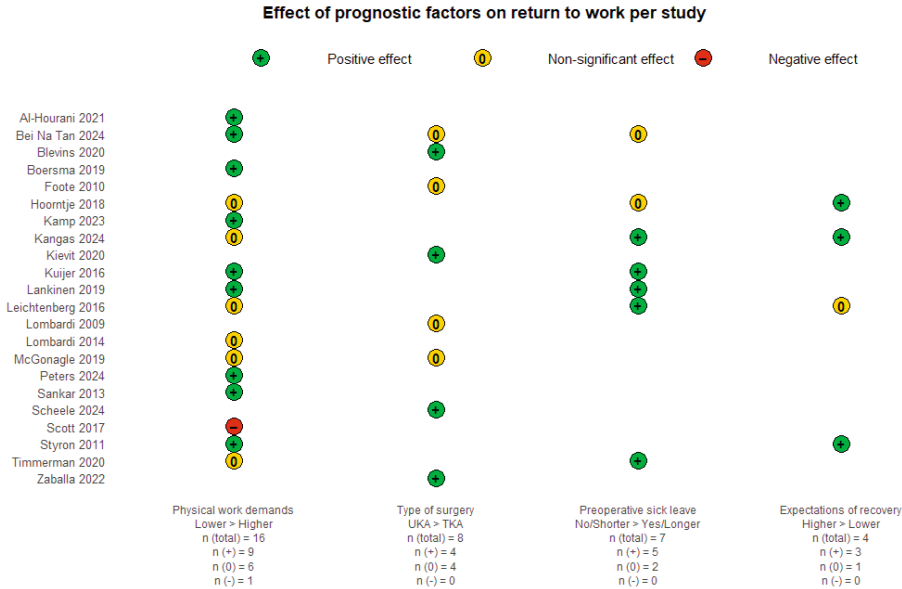


Figure 4: Harvest plot of included studies

Outcomes

All included studies reported outcomes related to return to work. However, the conceptualisation and operationalisation of return to work varied widely and were frequently insufficiently specified (Table 1). In the majority of studies, return to work was not explicitly defined as a distinct construct, but rather inferred from self-reported employment status, sick leave duration, or time to first work resumption, without a clear differentiation between partial or full return to work. Specifically, in most studies return to work was treated as a binary or time-to-event outcome reflecting any resumption of paid employment after surgery, irrespective of working hours, job demands, or contractual equivalence to the preoperative situation.

Only a limited number of studies clearly distinguished between initial (any) return to work and full return to work as separate outcomes. In these studies, initial return to work generally referred to the first resumption of work in any capacity (e.g. reduced hours, modified duties), whereas full return to work was defined as a return to preoperative working hours and job demands.^{58,60,65,71-73} Notably, even within this subgroup, the analytical use of these distinctions varied: for example, Leichtenberg combined partial and no return to work into a single category for analysis⁶⁵, and some studies reported full versus partial return to work descriptively without linking these outcomes to time-to-event analyses or prognostic modeling.

Follow-up

Specified follow-up periods ranged from 6 months⁷² to 119 months⁶³ (~0.5–9.9 years), with most cohorts followed for 12 months and several extending to ≥2 years; one study did not report follow-up.⁵⁶ In total, six studies reported multiple follow-up time points for return to work.^{22,58,61,63,70,72}

Excluded studies

After full-text assessment, 18 articles were excluded for predefined reasons (Figure 1). Four studies were excluded because the reported return to work outcome did not correspond to the predefined return to work constructs used in this review, such as the absence of a valid or operational return to work endpoint.^{41,50-52} Five studies were excluded because no separate analyses were available for patients with knee arthroplasty or for participants who were working preoperatively, thereby precluding attribution of prognostic effects to the target population.^{20,43,46,48,49} Six studies were excluded because the four prespecified prognostic factors for return to work were not measured or not analyzed in relation to return to work outcomes.^{39,40,42,52-54} Two reports were excluded due

to overlap with study populations already included in the review (Kaila-Kangas 2021⁴⁴ overlapping with Lankinen 2019⁶⁴; Kamp 2021⁴⁵ overlapping with Kamp 2023⁶¹). One study was excluded because the study population did not meet the eligibility criteria of the review (mixed or non-working populations without stratification).⁴⁷

In addition, three records identified in the updated search were excluded at full-text stage because two were conference abstracts without sufficient methodological detail or peer-reviewed full texts, and one because no separate analyses for knee arthroplasty were provided.⁴⁸

Risk of bias in included studies

Overall, the methodological quality of the included studies varied considerably, with the majority demonstrating multiple domains at high risk of bias [Figure 2](#). None of the 22 studies were judged to be free from high risk of bias across all domains, with only one study showing low risk of bias in the majority of assessed domains.⁷⁵

Study participation

We assessed thirteen studies (59%) as having low risk of bias for study participation. However, six studies^{56,57,59,62,64,69} showed moderate risk, and two studies^{55,70} demonstrated high risk of bias. The main concerns related to inadequate description of participation rates and the lack of information about non-participants' characteristics, limiting our ability to determine whether the samples adequately represented the target population in terms of key characteristics.

Study attrition

Study attrition showed better overall quality, with eleven studies (50%) rated as having low risk of bias. Seven studies^{21,22,58,60,62,67,69} demonstrated moderate risk of, while four studies^{56,57,65,73} were assessed as having high risk of bias, primarily due to response rates falling below our predetermined threshold of 75% or unclear reporting of attrition rates.

Prognostic factor measurement

Most studies adequately described their prognostic factors, with only three studies^{22,64,68} achieving low risk of bias. The majority (17 studies, 77%) showed moderate risk, while two studies^{60,71} demonstrated high risk of bias in this domain.

Artikel	Study Participation	Study Attrition	Prognostic Factor Measurement	Outcome Measurement	Study Covariates	Statistical Analysis and Reporting
Al-Hourani 2021	Low	Low	Moderate	High	High	High
Bei Na Tan 2024	High	High	Moderate	High	Moderate	High
Blevins 2020	High	High	Moderate	High	High	High
Boersma 2019	Low	Moderate	Moderate	Moderate	Moderate	High
Footo 2010	Moderate	Low	Moderate	High	High	Moderate
Hoornijte 2018	Low	Moderate	High	Moderate	High	Low
Kamp 2023	Low	Low	Moderate	Low	Moderate	Moderate
Kangas 2024	Moderate	Moderate	Low	Low	Low	Low
Kievit 2020	Low	Low	Low	High	High	Moderate
Kuijter 2016	Low	Moderate	Moderate	High	Low	Low
Lankinen 2019	Moderate	Low	low	low	Moderate	Moderate
Leichtenberg 2016	Low	High	Moderate	Low	Moderate	Moderate
Lombardi 2009	Moderate	Low	Low	High	High	High
Lombardi 2014	Low	Moderate	Moderate	High	High	High
McGonagle 2019	Low	Low	Low	Moderate	High	Moderate
Peters 2024	Moderate	Moderate	Moderate	Moderate	Moderate	High
Sankar 2013	Low	Moderate	Low	Low	High	High
Scheele 2024	Moderate	Low	Low	High	High	High
Scott 2017	Low	Low	High	Moderate	High	Moderate
Styron 2011	Moderate	Low	Moderate	Low	Moderate	Low
Timmerman 2020	Low	High	Moderate	Moderate	High	High
Zaballa 2022	Low	Low	Moderate	Moderate	High	High

Figure 2: QUIPS outcomes of the included studies

Outcome measurement

Outcome measurement showed considerable variation in quality. Six studies achieved low risk of bias through clear and comprehensive outcome definitions.^{22,61,62,64,65,72} However, seven studies (32%) showed moderate risk^{58,60,68,69,71,73,74}, and nine studies (41%) were rated as high risk of bias^{21,55-57,59,63,66,67,70}, often due to insufficiently detailed outcome descriptions that left uncertainty about specific inclusion criteria such as sick leave status or partial or full return to work.

Study covariates

This domain showed the most concerning results, with thirteen studies (59%) rated as having high risk of bias due to inadequate adjustment for essential confounders like preoperative sick leave or physical work demands. Only two studies^{21,62} achieved low risk of bias, while seven studies showed moderate risk of bias.^{56,58,61,64,65,69,72}

Statistical analysis and reporting

Statistical analysis and reporting quality was problematic across the sample, with eleven studies (50%) demonstrating high risk of bias due to selective reporting of significant associations or inadequate description of model building strategies. Seven studies showed moderate risk, while only four studies^{21,60,62,72} achieved low risk of bias through comprehensive and transparent reporting of their analytical approaches.

Findings

Return to work

Eighteen studies reported the proportion of patients returning to work at one or more follow-up time points (Figure 3). An overview of the main results for time to return to work and short- and long-term return to work proportions, together with the certainty of the evidence assessed using GRADE, is provided in the Summary of Findings tables (Summary of findings table 2; Summary of findings table 3; Summary of findings table 1; Summary of findings table 4). The pooled proportion of return to work in the short term (≤ 6 months) after surgery was 74% (7 studies, $n=3155$, 95% CI: 72-75), and 59% (1 study, $n=104$, 95% CI: 49-68) for full return to work. The pooled proportion of return to work in the long term (>6 months) was 82% (14 studies, $n=3160$, 95% CI: 81-83) and 72% (5 studies, $n=586$, 95% CI: 69-76) for full return to work. The pooled mean time to return to work (partial or full) was 90 days (10 studies, $n=2174$, 95% CI 87-93) and the pooled median time was 90 days (3 studies, $n= 500$, IQR: 60-150).

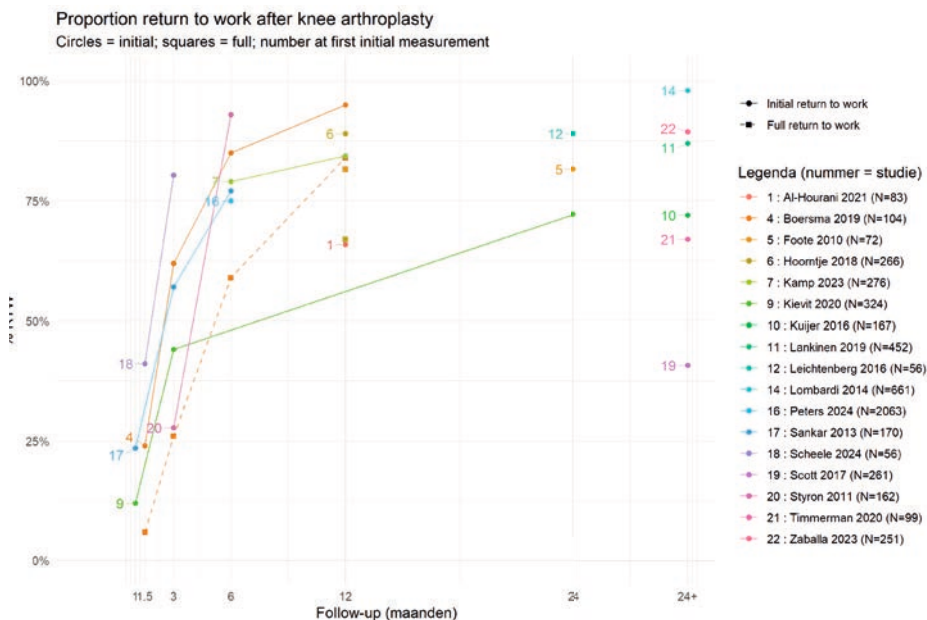


Figure 3: Spaghetti plot of percentage of patients who returned to work per follow-up

Prognostic factors

Physical work demands

Sixteen studies reported the association between physical work demands and either time to or proportion returning to work after knee arthroplasty (Figure 4).^{21,22,55,56,58,60-62,64,65,67-69,71-73} Ten studies were prospective (n=1,907) and six studies were retrospective (n=3,558) (Table 1). Six studies did not find a significant association between physical work demands and return to work.^{60,62,65,67,68,73} One study reported that higher physical work demands were associated with a higher proportion of patients returning to work.⁷¹ The remaining six studies reported that lower physical work demands were associated with a shorter time to return to work or higher proportion of patients returning to work.^{55,56,58,61,69,72}

Definition of prognostic factor

The prognostic factor physical work demands was operationalized in three ways. Most studies relied on self-reported occupation- or job title-based proxies, such as white- versus blue-collar workers^{56,61,64} or categorical intensity levels (low/medium/high)^{22,73}, with specific contrasts such as high knee-demanding versus light knee demanding²¹ or low- versus medium-impact work⁶⁹. Also standardized, Dictionary of Occupational Titles (DOT)-based demand categories were used (sedentary, light, medium, heavy, very heavy), including dichotomizations like heavy/moderate versus light/sedentary.^{55,67-69}

Self-reported measures were also used as continuous scales, including a task-based workload sum score ranging from 0 to 20⁶² and a physical-demands score modeled per standard deviation, derived from a self-reported knee-specific occupational demand scale and entered as a continuous predictor.⁷² Finally, expert coding of job titles by occupational experts using occupational-medicine criteria was also used in terms of high or low physical work demands.^{60,65} One study categorized the work demands as mainly physical, mainly mental, or a mix of both.⁵⁸ No Job Exposure Matrices were used and no activity trackers or other measurement devices were used to assess the physical work demands.

Time to return to work

Two studies reported the association between physical work demands and the time to return to work after knee arthroplasty.^{61,64} Higher physical work demands were associated with a longer time to return to work (pooled HR = 0.52, 95% CI 0.35-0.78; $I^2 = 0\%$ (Figure 5).^{61,64}

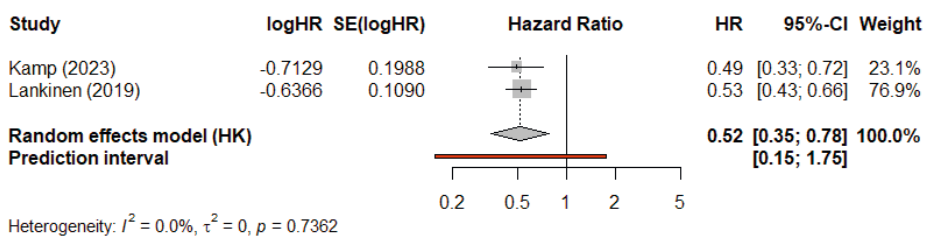


Figure 5: Forest plot of time to return to work and physical work demands

Proportion returning to work

Nine studies reported the association between physical work demands and either time to or proportion returning to work after knee arthroplasty.^{21,55,56,60,65,67,69,71,73} Higher physical work demands were not associated with a higher or lower proportion of patients returning to work (pooled RR = 1.58, 95% CI 0.78-3.17; $I^2 = 79\%$) (Figure 6). Stratified by return to work definition (excluding “undefined”), physical work demands were not associated with a higher or lower proportion of initial return to work (RR = 0.79, 95% CI 0.00-887.35; $I^2 = 77.9\%$)^{71,73} or full return to work (RR = 0.52, 95% CI 0.03-7.88; $I^2 = 0\%$)^{60,65} (Figure 6). By the follow-up window of less or more than six months, the short-term estimate came from one study⁶⁹ and showed that higher physical work demands were associated with a higher non-return to work (RR = 2.83, 95% CI 2.31-3.46), whereas the long-term pooled estimate found no statistically significant positive or negative association (RR = 1.19, 95% CI 0.50-2.83; $I^2 = 67\%$; p for subgroup difference = 0.019)^{21,55,60,65,67,71,73} (Figure 7).

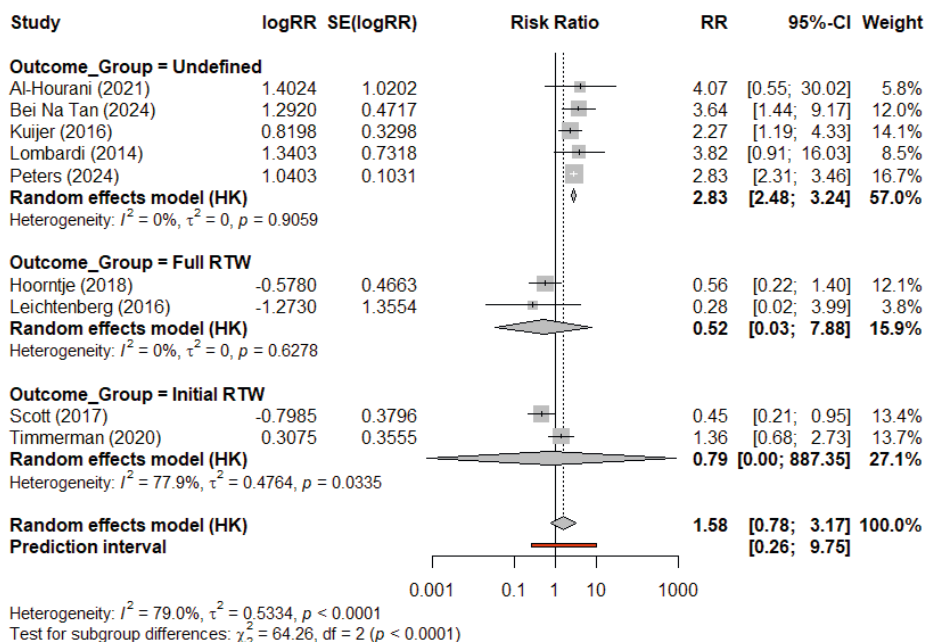


Figure 6: Forest plot of proportion returning to work with physical work demands per outcome

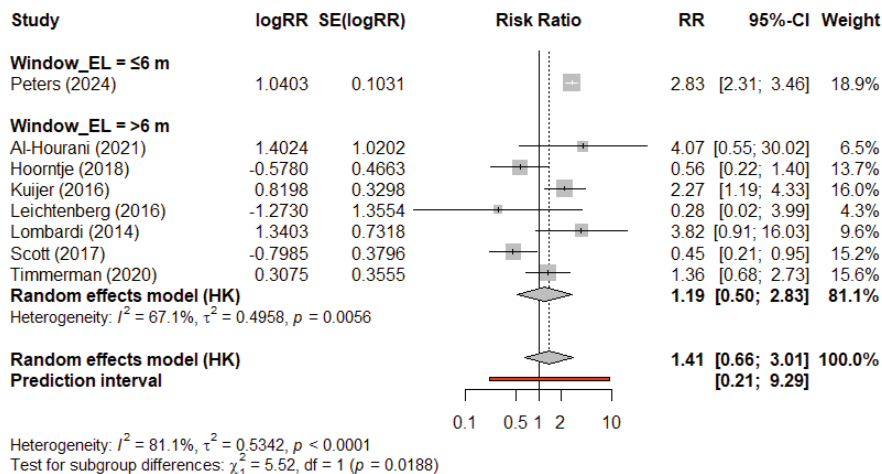


Figure 7: Forest Plot of proportion returning to work with physical work demands per timeframe follow-up

Type of arthroplasty

Eight studies reported the association between the type of arthroplasty (UKA versus TKA) and either time to or proportion returning to work after knee arthroplasty (Figure 4).^{56,57,59,63,66,68,70,74} All studies were retrospective (n=1,763). Four studies did not find a significant association between type of arthroplasty and return to work.^{56,59,66,68} The remaining four studies reported that UKA was associated with a shorter time to return to work or higher proportion of patients returning to work.^{57,63,70,74}

Time to return to work

Four studies reported the association between the type of arthroplasty and the time to return to work after knee arthroplasty.^{56,57,66,68} The pooled mean difference showed no significant association between the type of arthroplasty and the time to return to work (MD=5.1, 95%CI: -16.1 to 26.3; $I^2 = 90.3\%$) (Figure 8).

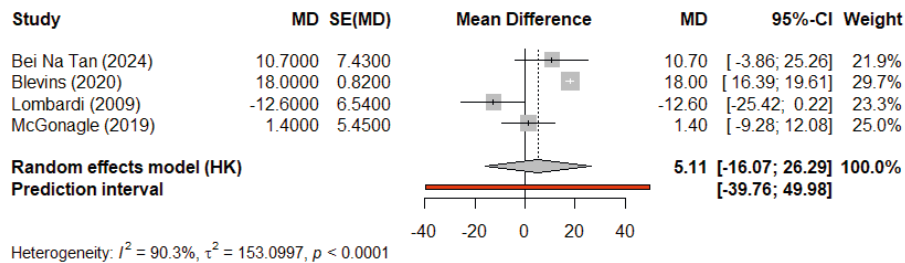


Figure 8: Forest plot of mean difference of time to return to work with type of arthroplasty

Proportion of return to work

Five studies reported the association between the type of arthroplasty and either time to or proportion returning to work after knee arthroplasty.^{56,59,63,70,74} UKA was associated with more return to work compared to TKA (RR = 1.92, 95% CI 1.42-2.58; $I^2 = 0\%$). All included studies had return to work outcomes classified as “undefined” regarding their specific definitions. By the follow-up window of less or more than six months, the short-term (RR = 2.18, 95% CI 0.04-120.24; $I^2 = 23\%$)^{63,70} and long-term (RR = 1.85, 95% CI 0.93-3.65; $I^2 = 0\%$)^{56,59,74} pooled estimates found no statistically significant positive or negative association (Figure 9).

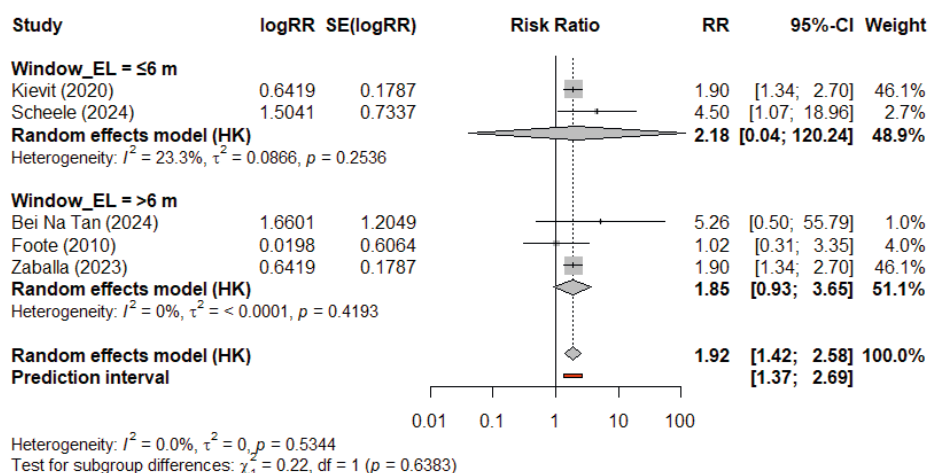


Figure 9: Forest plot of proportion returning to work with type of arthroplasty per outcome

Preoperative sick leave

Seven studies reported the association between preoperative sick leave and either time to or proportion returning to work after knee arthroplasty (Figure 4).^{21,56,60,62,64,65,73} Four studies were prospective ($n=889$) and three studies were retrospective ($n=776$) (Table 1). Two studies did not find a significant association between preoperative sick leave and return to work.^{56,60} The remaining five studies reported that a longer duration of, or the presence of, preoperative sick leave was associated with a shorter time to return to work or higher proportion of patients returning to work.^{21,62,64,65,73}

Definition of prognostic factor

The prognostic factor preoperative sick leave was operationalized in three ways. First, as a binary indicator of any preoperative sick leave^{56,65}, second, as duration or extent of preoperative sick leave (weeks/months or percentage time off)^{21,73}, and last as preoperative sick leave history from records or self-report.⁶⁰

Time to return to work

Two studies reported the association between preoperative sick leave and time to return to work.^{62,64} One study compared ≤ 30 days versus > 30 days of preoperative sick leave and found that having ≤ 30 days of preoperative sick leave was associated with a higher hazard of return to work (HR 0.45, 95% CI 0.34–0.58).⁶⁴ Another study analyzed five categories of preoperative sick leave duration (0–5 days, 6–20 days, 21–60 days, 60–90 days, > 90 days) and reported that each

step towards a category with more preoperative sick leave days was associated with an additional 16-day delay in return to work.⁶² Because of heterogeneity in outcome definitions no pooled analysis was performed.

Proportion of return to work

Five studies reported the association between preoperative sick leave and proportion returning to work after knee arthroplasty.^{21,56,60,65,73} Longer preoperative sick leave or the presence of preoperative sick leave was not associated with a significant higher or lower proportion of patients returning to work (RR = 2.27, 95% CI 0.96-5.35; $I^2 = 94\%$)(Figure 10). Since all studies were short term or had an undefined follow-up period, no subgroup analysis for return to work was performed. Subgroup analyses by study design showed no association with a higher or lower proportion of patients returning to work with a pooled RR of 1.60 (95% CI 0.03-95.59; $I^2 = 18\%$) for prospective studies and 3.28 (95% CI 0.22-49.55; $I^2 = 98\%$) for retrospective studies.

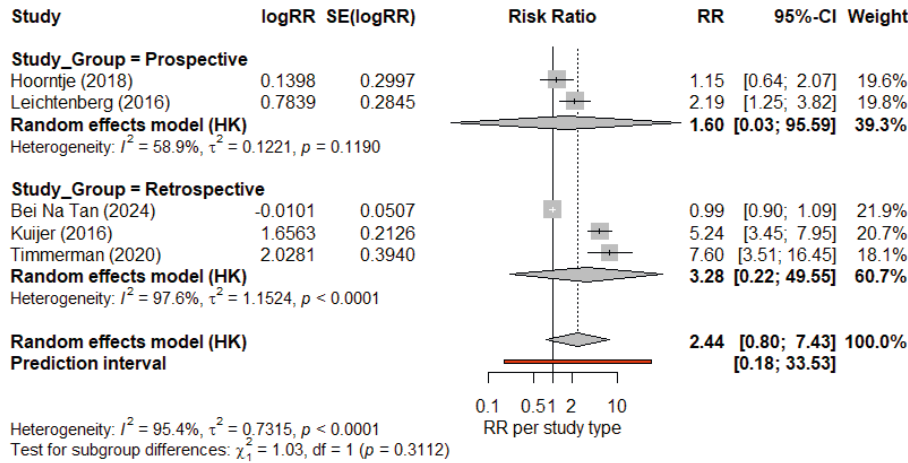


Figure 10: Forest plot of proportion returning to work with preoperative sick leave per study type

Expectations

Four studies reported the association between patient expectations and either time to or proportion returning to work after knee arthroplasty (Figure 4).^{60,62,65,72} All four studies were prospective (n=599). One study did not find a significant association between patient expectations and return to work.⁶⁵ Three studies reported that more favorable preoperative expectations were associated with earlier and/or higher likelihood of returning to work.^{60,62,72} Because the

operationalizations for preoperative expectations varied considerably, we did not pool results and summarized each study separately.

Definition of prognostic factor

The prognostic factor expectations was operationalized in four ways: (1) expected timing of return to work in weeks preoperatively (continuous)⁶⁰; (2) a single item reflecting a personal sense of urgency to return to work (0–1 scale) plus parallel time-to-event and 3-month yes/no return to work models⁷²; (3) patients' own expected length of sick leave and "positive expectations about time to return to work," analyzed alongside other factors⁶²; and (4) an item from the Hospital for Special Surgery (HSS) Expectation Survey dichotomized to "back to normal" vs "less than back to normal" for paid work.⁶⁵

Time to return to work

Two studies reported the association between patient expectations and the time to return to work.^{62,72} In a TKA cohort from the United States of America, a stronger sense of urgency to return to work was associated with a shorter time to return to work: the acceleration factor (AF) was 0.47 for both any return to work and full-time return to work—i.e., about half the time compared with peers ($p < 0.001$).⁷² In a Finnish multicenter cohort study implementing a coordinated return to work model, regression and dominance analyses identified patients' own expectations about time to return to work as among the strongest prognostic factors for a shorter time to return to work, even after adjusting for physical work demands, preoperative sick leave, and motivation.⁶² Because of heterogeneity in outcome definitions no pooled analysis was performed.

Proportion of return to work

Three studies reported the association between patient expectations and the proportion of patients returning to work after knee arthroplasty.^{60,65,72} More favorable or more urgent preoperative expectations were not consistently associated with a higher or lower proportion of patients returning to work. One study reported that a stronger preoperative sense of urgency to return to work was associated with a higher proportion of patients returning to work within three months, both for any return to work (RR 1.44, 95% CI 1.16–1.79) and full-time return to work (RR 1.54, 95% CI 1.17–2.03).⁷² One study reported that a stronger preoperative sense of urgency to return to work was associated with a higher proportion of patients returning to work within three months.⁷² Similarly, a longer expected duration of absence from work before surgery was associated with a lower likelihood of full return to work at 12 months.⁶⁰ In contrast, another study found no association between dichotomised expectations and return to

work status at 12 months.⁶⁵ Because of heterogeneity in outcome definitions, follow-up periods, and operationalisation of expectations, no pooled analysis was performed.

Certainty of the evidence (GRADE)

Certainty of the evidence for each prespecified outcome—time to return to work, proportion returning to work in the short term (≤ 6 months), and proportion returning to work in the long term (> 6 to 36 months)—was assessed using the GRADE approach adapted for prognostic factor research. Evidence was initially considered high certainty and subsequently downgraded based on risk of bias, inconsistency, indirectness, and imprecision.

Across prognostic factors, certainty of evidence ranged from low to very low. Downgrading was primarily driven by methodological limitations identified in the QUIPS assessment, particularly in the domains of study covariates and statistical analysis. Many studies did not adequately adjust for key occupational and participation-related confounders, including preoperative sick leave duration, job demands, and workplace accommodations.

Inconsistency was observed for several associations, especially for proportion-based return to work outcomes, where effect estimates varied substantially across studies and heterogeneity was frequently high. Indirectness was common due to heterogeneous and often undefined return to work constructs, with limited distinction between initial and full return to work. Imprecision further contributed to downgrading where confidence intervals were wide or the number of contributing studies was small.

Directionally consistent associations were most evident for time-to-event outcomes in relation to preoperative sick leave and expectations; however, even for these outcomes, certainty did not exceed low due to residual confounding and limited study numbers. For physically demanding work and type of arthroplasty, certainty was frequently very low, reflecting inconsistent findings and methodological limitations.

The detailed certainty assessments for each prognostic factor and outcome are presented in the Summary of Findings tables (Summary of findings table 2; Summary of findings table 3; Summary of findings table 1; Summary of findings table 4).

Directed Acyclic Graph

Although a directed acyclic graph (DAG) was prespecified to support causal reasoning, the available evidence did not allow for the construction of a data-informed DAG. Across the included studies, the overall certainty of evidence was low to very low, with substantial heterogeneity in study designs, outcome definitions, follow-up durations, and operationalisations of the prognostic factors. In addition, most studies reported limited and inconsistent adjustment for potential confounders, and several key causal assumptions could not be empirically evaluated. As a result, we refrained from presenting a formal DAG and instead described the relationships between the prognostic factors and return to work narratively, based on the direction, consistency, and plausibility of the observed associations.

Discussion

Summary of main results

This systematic review synthesized evidence on four preoperative prognostic factors—physical work demands, type of arthroplasty, preoperative sick leave, and patients' expectations regarding recovery—in relation to return to work among patients having knee arthroplasty. Interestingly, out of the 34 investigated associations, only one was in the opposite direction than we expected, namely that lower physical demanding work was associated with a worse return to work outcome (Figure 4).

For time to return to work, more consistent prognostic associations were observed for preoperative sick leave and patients' expectations regarding recovery, with longer preoperative sick leave and less favorable expectations generally associated with delayed return to work. In contrast, for return to work proportions, particularly short- and long-term proportions, associations for physical work demands, type of arthroplasty, preoperative sick leave, and patients' expectations regarding recovery were frequently absent or inconsistent across studies. As a result, null associations were common for proportional outcomes across all four prognostic factors, whereas time-to-event analyses more often demonstrated directionally consistent associations for selected prognostic factors.

Overall, the evidence indicated that return to work after knee arthroplasty is influenced by multiple interacting prognostic factors, with the presence and strength of associations depending on both the prognostic factor under study

and the outcome definition used. (Summary of findings table 2; Summary of findings table 3; Summary of findings table 1; Summary of findings table 4).

Interpretation of findings

Return to work as a participation-oriented outcome

The present findings should be interpreted in light of return to work as a participation-oriented outcome rather than a purely biomedical endpoint among patients having knee arthroplasty. Returning to work reflects the resumption of a meaningful societal role and is shaped by physical capacity, psychological readiness, workplace demands, and broader social and policy contexts. Qualitative and mixed-methods research among patients having knee arthroplasty consistently highlights work participation as a central indicator of recovery, identity, and social value for working-age individuals.

The substantial heterogeneity in return to work outcomes observed across studies likely reflects these multidimensional influences. Even when clinical recovery is satisfactory, participation outcomes may lag behind, particularly in patients with prolonged preoperative sick leave or in contexts with limited opportunities for workplace adaptation. This helps explain why prognostic associations for physical work demands, type of arthroplasty, preoperative sick leave, and patients' expectations regarding recovery were often directionally plausible yet quantitatively variable, and why consistent associations across outcome definitions were rarely observed.

Interpretation of individual prognostic factors

Across the included studies, physical work demands, type of arthroplasty, preoperative sick leave, and patients' expectations regarding recovery showed heterogeneous prognostic associations with return to work outcomes.

Preoperative sick leave demonstrated the most coherent prognostic signal, particularly for time-to-event outcomes. Longer duration of preoperative sick leave was associated with delayed return to work in available time-to-event analyses. However, for short- and long-term return to work proportions, associations for preoperative sick leave were inconsistent and frequently non-significant, underscoring that preoperative sick leave should be interpreted as a prognostic factor rather than as a deterministic indicator.

For the heterogeneous definition of physical work demands, prognostic associations were inconsistent across both time-to-event outcomes and return to work proportions. Although biological and functional plausibility exists, effect estimates varied widely, including null and opposing associations. This suggests

that the prognostic relevance of physical work demands is likely context-dependent and influenced by factors such as workplace accommodations and job flexibility rather than exerting a uniform association across settings.

Regarding type of arthroplasty, some studies suggested earlier return to work after unicompartmental compared with total knee arthroplasty, particularly in pooled analyses. However, these prognostic associations were not robust across prespecified time horizons, and time-stratified analyses frequently showed no clear association. Confounding by patient selection, baseline functional status, and occupational context likely limits the independent prognostic value of type of arthroplasty.

Patients' positive expectations regarding recovery were associated with faster time to return to work in several studies, supporting prior evidence that expectations are an important prognostic factor for participation. Nevertheless, variation in expectation constructs and measurement approaches, together with frequently null associations for proportional outcomes, resulted in imprecise estimation of the magnitude of these prognostic associations.

Methodological considerations and limitations

Heterogeneity in outcome definition and measurement

A major limitation across the included studies was the heterogeneity in the definition and measurement of return to work. Studies variably reported initial return to work, full return to work, or did not distinguish between these outcomes, and both dichotomous and time-to-event measures were used across widely varying follow-up periods. Failure to distinguish between partial and full return to work may obscure clinically relevant differences in recovery trajectories and sustainable work participation. The lack of standardized outcome definitions remains a key barrier to evidence synthesis in occupational health research and has been repeatedly highlighted in Cochrane reviews.^{76,77}

Confounding and analytical limitations

Adjustment for confounding factors varied considerably across studies. While age and sex were commonly included, key occupational and participation-related variables—such as preoperative sick leave duration, physical work demands, and workplace accommodations—were often omitted or incompletely measured. Consequently, residual confounding is likely, particularly for prognostic factors that are closely intertwined with the work context.

Risk of bias assessment using the QUIPS tool indicated that the domains of study covariates and statistical analysis were most frequently rated as moderate or high risk of bias. These limitations are consistent with earlier reviews of prognostic research in musculoskeletal disorders and restrict confidence in the magnitude of observed associations.²⁹

Contextual influences

Return to work is strongly shaped by national social security systems, workplace policies, and access to occupational health services. The inclusion of studies from diverse countries with differing labor market regulations likely contributed to between-study heterogeneity and limits the direct transferability of effect estimates across settings.

Applicability of the evidence

The findings of this review are most applicable to working-age adults having primary knee arthroplasty in high-income countries with structured healthcare and social security systems. Caution is warranted when extrapolating results to settings with substantially different occupational health infrastructures or informal labor markets.

Importantly, the identified prognostic factors should not be interpreted as deterministic predictors for individual patients. Instead, they may support the identification of individuals at increased risk of a delayed return to work after surgery, particularly when multiple prognostic factors co-occur.

Certainty of the evidence

Across all prognostic factors and outcomes, certainty of evidence ranged from low to very low, as summarised in the Summary of Findings tables. Downgrading was primarily driven by risk of bias, inconsistency of results, indirectness related to heterogeneous and often undefined return to work constructs, and imprecision of effect estimates. While several associations were directionally consistent, the overall certainty limits strong inferences regarding prognostic strength.

Comparison with existing literature

Based on the two most recent reviews on prognostic factors for return to work after knee arthroplasty, the present review suggests lower certainty regarding the previously reported favorable associations of low physical work demands and UKA with return to work.^{19,78} This more cautious interpretation primarily reflects substantial heterogeneity in outcome definitions, follow-up periods, and adjustment for confounders, as well as the formal application of risk of bias and GRADE assessments. In contrast, our findings support the relevance

of preoperative sick leave and patients' expectations regarding recovery as prognostic factors for time to return to work, although the overall certainty of evidence remains limited.

Consistent with earlier systematic reviews, we observed considerable variation in return to work outcomes across studies.^{18,78} However, the present review extends previous work by explicitly differentiating between time-to-event and proportion-based return to work outcomes, distinguishing short- and long-term follow-up windows, and systematically evaluating the certainty of the evidence. This more granular analytical approach resulted in a more nuanced interpretation of the strength and consistency of associations.

Overall, our findings reinforce prior observations that work participation remains insufficiently integrated into prognostic research and conventional postoperative care pathways, despite its clear importance for patients, employers, and society.^{16,79}

Implications for practice

The identified prognostic factors may support clinicians in discussing realistic expectations regarding return to work with patients considering knee arthroplasty. Rather than serving as predictive tools, these factors can inform shared decision-making and help identify patients who may benefit from additional, work-directed support.

Integrating work-related considerations into perioperative consultations aligns with patient-centred and value-based care frameworks that emphasise outcomes meaningful to patients, including participation and societal roles.^{80,81}

Implications for research

Future studies should adopt standardized, consensus-based definitions of return to work, distinguishing between initial and full return and using harmonised follow-up windows. Implementation of emerging core outcome sets for work participation is essential to improve comparability across studies.

Prospective studies with predefined confounder adjustment strategies, transparent reporting, and adequate measurement of occupational context are needed to strengthen prognostic inference.

Individual participant data meta-analyses may further elucidate how prognostic factors interact across occupational and healthcare contexts.

Authors' conclusions

Evidence for preoperative prognostic factors for return to work after knee arthroplasty is of low to very low certainty, and associations vary by outcome definition and analytical approach. Preoperative sick leave and patients' expectations regarding recovery are most consistently associated with time to return to work, but conclusions are constrained by heterogeneity, risk of bias, and imprecision.

Additional information

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Editorial and peer-reviewer contributions

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Contributions of authors

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Data collection for the review: DOS, ACS, and PPFMK

Designing search strategies: DOS, ACS, and PPFMK

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Registration and protocol

This review was registered in the Cochrane Database of Systematic Reviews (protocol: CD015272).

Data, code and other materials

The data underlying this review, including extracted datasets, analytic code, and supplementary materials, are available from the corresponding author upon reasonable request.

Note to editor/reviewer:

Supplementary material 2; Supplementary material 3; Supplementary material 4 are available in Table 1 and Figure 2

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CHAPTER

9

Sedentary behaviour after surgery is associated with delayed full return to work among patients receiving knee arthroplasty within the Back At work After Surgery (BAAS) work-integrated care cohort

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Abstract

Background: Sedentary behaviour and low physical activity may influence recovery after knee arthroplasty (KA) in working-age patients. This hypothesis-generating study investigates whether perioperative physical activity levels are associated with time to full return to work (RTW).

Methods: Working-age patients ($n = 121$) in the multicentre BAAS cohort wore ankle accelerometers from 6 weeks pre- to 6 weeks post-surgery. Daily activity and sedentary episodes were analysed using generalised linear models with days to RTW as outcome.

Results: Median RTW was 113 days (IQR 80–153). Preoperatively, each additional 10 min/day of moderate activity was associated with six fewer days to RTW ($\beta = -0.63$, 95% CI -1.1 to -0.1), while each additional minute of vigorous activity was associated with four more days to RTW ($\beta = 4.17$, 95% CI 2.1 – 6.3). Additional sedentary episodes showed a borderline association with earlier RTW ($\beta = -3.17$, 95% CI -6.39 to 0.05). Postoperatively, each additional sedentary episode was associated with two more days to RTW ($\beta = 2.31$, 95% CI 0.2 – 4.4).

Conclusion: Moderate preoperative activity was associated with earlier RTW, while vigorous pre- and postoperative sedentary behaviour was associated with delayed RTW. No other activity measures were associated with RTW.

Keywords: Physical activity, return to work, knee arthroplasty, rehabilitation, sedentary behavior

Background

In today's society, the negative consequences of physical inactivity have become increasingly prevalent, underscoring the sedentary epidemic.^{1,2} The World Health Organization identifies insufficient activity as a leading global risk factor for mortality and chronic diseases.¹ For example, individuals who mainly sit at work have higher risks of mortality (16%) and cardiovascular diseases (34%) than those who do not.³ However, large meta-analyses suggest that high levels of moderate-to-vigorous physical activity may attenuate or even eliminate the excess mortality risk associated with prolonged sitting.⁴ Dutch residents are 'European champions' of sitting, 26% of those aged ≥ 15 years sit over 8.5 hours daily, far above the European average of 11%.⁵ Daily life, dominated by sitting at desks, screens, or in vehicles, poses a significant public health challenge, requiring urgent action. This challenge magnifies in clinical contexts, especially hospitalizations such as surgery.

Surgical interventions, while often necessary, can further promote sedentary behavior.⁶ Recovery typically restricts mobility, increasing inactivity and reducing physical activity.⁷ Compounded by physiological impairment and depleted reserves, this raises the risk of severe deterioration, including delayed recovery, more complications and prolonged convalescence.^{8,9}

Physical activity after surgical intervention matters not only for clinical recovery but return to work (RTW), an overlooked outcome for working-age patients.^{10,11} Work participation supports income and values such as skill-use, skill-growth, decision-influence, relationships, autonomy, and societal contribution, meaning and identity.¹² Work also predicts long-term health.¹³ Attention to RTW is especially relevant after knee arthroplasty (KA), given the rising numbers of working-age patients needing surgery and poor RTW outcomes.^{14,15}

Accelerometer data show that working-age patients with KA remain highly sedentary a year post-surgery, especially desk workers, who do not compensate for their occupational sedentary time by increasing physical activity during leisure time.⁷ Evidence linking activity to RTW is conflicting, highlighting the need to clarify whether reliably measured activity and sedentary behavior before and after surgery relate to timely work resumption.^{7,16-18}

In this hypothesis-generating study, we aim to answer the research question: what is the association between pre- and postoperative levels of physical activity with days to full RTW after KA in the Netherlands?

Methods

This study was reported in line with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.¹⁹

Study design

This study has an observational cohort design, using data from the multicenter prospective Back At work After Surgery (BAAS) study, aimed at improving RTW following KA.²⁰ Patients in the BAAS cohort were consecutively included between November 2021 and April 2023, with prospective follow-up for 12 months after surgery. Within the BAAS pathway, accelerometer data were systematically collected to measure physical activity and sedentary behavior. Previously, the BAAS study assessed the feasibility, effectiveness and return on investment of this comprehensive care pathway, providing a dataset including accelerometer measurements.²⁰⁻²³

Study setting and participants

The BAAS cohort included 145 patients. Inclusion criteria, exclusion criteria and recruitment are described in our protocol paper.²⁰ Daily physical activity data of each patient were included when: (1) the accelerometer was worn at least 6 hours between 06:00 AM and 11:00 PM, and (2) the measured day was between 6 weeks prior to and 6 weeks after surgery. The study was conducted in two Dutch hospitals, a regional (Nij Smellinghe hospital Drachten, ≈430 KA/year) and a teaching hospital (Elisabeth-TweeSteden Hospital Tilburg, ≈770 KA/year).

BAAS work-integrated care pathway

Once KA was indicated, patients were referred for preoperative counseling and assessment by a hospital-based physical therapist. In this consultation, patients received counseling to optimize their preparation for surgery. Standardised questionnaires, functional tests and a work-related therapy goal were established using Goal Attainment Scaling (GAS).²⁴ An occupational assessor conducted a workplace assessment to identify RTW barriers and facilitators.

At 4-5 weeks post-surgery, an online team meeting was held with the patient, primary care physical therapist, hospital-based physical therapist, occupational assessor, and occupational physician to evaluate recovery and adjust the RTW plan. Hospital follow-ups were scheduled at 6 weeks and every 3 months until 12 months or full RTW. Recovery was monitored with GAS, questionnaires and functional tests.

Postoperative care included guideline based physical therapy in primary care.²⁵ When RTW within 12 months seemed unlikely, based on patient progress clinical assessments, and accelerometer data, patients were referred to an academic center for a multidisciplinary rehabilitation. This assessment could lead to participation in a vocational rehabilitation program.

Accelerometer

Participants were asked to wear a 3-axial ankle-mounted Physical Activity Monitor (PAM 2.0; Pam, Oosterbeek, The Netherlands). The PAM shows strong agreement with the ActiGraph wGT3X-BT (ICC of 0.955), a well-established and valid accelerometer to measure physical activity in patients with impaired gait.^{26,27} The PAM accelerometer has a user-friendly interface (Atris, Peercod, Geldermalsen, The Netherlands.) for the patient.

The PAM captures movement intensity through acceleration, quantified as Metabolic Equivalent of Task (kcal/kg/hour; MET) values, measured per second. It registers movements above a 1.4 MET threshold, defined as 'active minutes'.²⁶ These active minutes are categorized into light (1.4 – 3 METs), moderate (>3-7 METs), and vigorous (>7 METs) intensity during the wearing period.²⁸ Additionally, the sensor generates a daily overview segmenting the daytime into 15-minute bouts and calculates the mean METs for each interval.

Participants were able to view their activity minutes through the Atris mobile app, which interfaced with the PAM and was installed on their mobile phones.

Outcome Measures

The dependent variable full RTW was defined as: time in days from surgery to the first day a participant resumed the number of hours stated in his or her employment contract, regardless of the tasks performed. For self-employed patients, full RTW was defined as: first day a participant works the number of hours equal to the number of hours he or she worked prior to surgery.

The association between full RTW and six independent variables were evaluated, pre- and postoperative. These six were:

1. Minutes light intensity (1.4–3 METs);
2. Minutes moderate intensity (>3–7 METs);
3. Minutes vigorous intensity (>7 METs);
4. Daily MET value (sum of average MET values over 15-minute intervals);
5. Frequency of sedentary behavior (daily frequency of continuous sedentary episodes of ≥ 30 min, defined as two consecutive 15-min bouts of <1.4 METs));
6. Percentage adherence to the Dutch physical activity guidelines 2017 (>150 weekly minutes of Moderate to Vigorous Physical Activity (MVPA; >3 METs), 150 min=100%, 75 min=50%, 300 min=200%).²⁹

Analysis

Analyses were performed using Python (version 3.12.7) and the statistical library SciPy (version 1.13.1). Statistical significance was defined as $p < 0.05$.

Descriptive statistics were used to summarise characteristics of the patient sample, the six physical activity variables (independent) and the primary outcome, full RTW (dependent). For normally distributed data, the mean and standard deviation (SD) were reported. For non-normally distributed data, the median and interquartile range (IQR) were used.

Distribution of continuous variables was assessed visually (histograms, Q–Q plots) and with the Shapiro–Wilk test. Levene’s test was used to evaluate the homogeneity of variances.

To describe the changes in the six physical activity variables before and after surgery, paired comparisons were conducted. For normally distributed variables with equal variances, paired t-tests were used. For non-normally distributed variables, the Wilcoxon signed-rank test was applied.

To answer the research question, a univariate generalised linear model (GLM) with a Gaussian distribution and identity link was used to assess associations between the six independent physical activity variables, both for pre- and postoperative measurements, and full RTW (in days). Each model included one prognostic factor as an independent variable, with the primary outcome as a dependent variable. Results were expressed as unstandardised regression coefficients (β), representing the change in days to full RTW per one-unit increase in the independent variable with corresponding standard errors, 95% confidence intervals and p values.

Results

Accelerometer data were available for 121 patients. All participants achieved full RTW within the 12-month follow-up period; therefore, no observations were censored and all patients were included in the regression analyses.

In total, 2,128 preoperative days and 3,584 postoperative days were included for analysis. The median number of days was 20 preoperatively (IQR 9–32) and 37 postoperatively (IQR 26–42). All physical activity variables were non-normally distributed; therefore, descriptive statistics are presented as medians and interquartile ranges (IQR) (Table 1). For all variables, Levene's test indicated unequal variances except for age and BMI. The Wilcoxon signed-rank test indicated that significant median changes in all activity measures between pre- and postoperative periods. Daily MET scores decreased by a median of 16.8 METs ($p<0.001$), light activity by 31 min/day ($p<0.001$), and moderate activity by 35 min/day ($p<0.001$). Vigorous activity decreased by three min/day ($p<0.001$). Sedentary episodes increased by 2 per day ($p<0.001$). MVPA guideline adherence fell by 146 percentage points ($p<0.001$). All corresponding medians and interquartile ranges are presented in Table 1.

Table 1. Descriptive statistics of pre- and postoperative physical activity data and full RTW outcomes

	N	Mean/Percentage	SD
Age	121	58	4.3
Sex (% male)	121	45%	
BMI (kg/m ²)	121	29	3.8
Type of surgery (%TKA)	121	69%	
Preoperative PA measures			
	N	Median/Percentage	IQR
Participants	121		
Valid measured days (>6h)	121	20	9–32
Light PA (min/day)	121	108	83 – 145
Moderate PA (min/day)	121	60	39 – 87
Vigorous PA (min/day)	121	3	1 – 5
Daily MET (kcal/kg/day)	121	62	47 – 77
Sedentary Behavior (episodes/day)	121	8	6 – 11
MVPA Adherence to guideline (%)	121	263%	175– 376
Postoperative PA measures			
Participants	121		
Valid measured days (>6h)	121	37	26–42

Table 1. continued

	N	Mean/Percentage	SD
Light PA (min/day)	121	77	57 – 100
Moderate PA (min/day)	121	25	12 – 43
Vigorous PA (min/day)	121	0	0 – 1
Daily MET (kcal/kg/day)	121	46	33 – 58
Sedentary Behavior (episodes/day)	121	10	8 – 13
MVPA Adherence to guideline (%)	121	117%	57 – 199
Outcomes			
Full RTW (days)	121	113	80-153

IQR = interquartile range (25th–75th percentile); RTW = Return to work; MET = Metabolic Equivalent of Task; MVPA = moderate to vigorous physical activity; PA = physical activity.

Trends of four physical activity variables from 6 weeks pre- until 6 weeks postoperatively are shown in Figure 1. Daily MET value and guideline adherence are directly derived from the four physical activity variables below and therefore not presented.

Univariate linear regression of preoperative physical activity variables showed moderate activity (min/day) was significantly associated with fewer days to full RTW ($\beta = -0.63$, 95% CI -1.14 to -0.12) and vigorous activity (min/day) with more days to full RTW ($\beta = 4.17$, 95% CI 2.05 to 6.29 ; Table 2). Based on model estimates, an additional 10 minutes of moderate or vigorous activity per day was associated with approximately 6 fewer or 42 more days to full RTW, respectively. Noted is the borderline significance of sedentary behavior preoperatively ($\beta = -3.17$, 95% CI -6.39 to 0.05). All other analyses were not significant.

Postoperative physical activity variables showed that sedentary behavior (episodes/day) was significantly associated with more days to full RTW ($\beta = 2.31$, 95% CI 0.23 to 4.40 ; Table 2). Each additional sedentary episode per day was associated with a delay of approximately 2 days in full RTW. All other analyses were not significant.

Table 2: Univariate linear regression results for preoperative and postoperative physical activity variables and Full RTW (in days)

Variable	β	Std. Error	p-value	95% CI (β)
Preoperative				
MET (kcal/kg/day)	0.24	0.19	0.20	-0.13 to 0.62
Light Activity (min/day)	-0.11	0.15	0.48	-0.42 to 0.20
Moderate Activity (min/day)	-0.63	0.26	0.015	-1.14 to -0.12
Vigorous Activity (min/day)	4.17	1.08	<.001	2.05 to 6.29
Sedentary Behavior (episodes/day)	-3.17	1.65	0.05	-6.39 to 0.05
MVPA Adherence (%)	0.05	0.04	0.26	-0.04 to 0.14
Postoperative				
MET (kcal/kg/day)	0.31	0.21	0.19	-0.15 to 0.78
Light Activity (min/day)	-0.13	0.14	0.37	-0.41 to 0.16
Moderate Activity (min/day)	-0.18	0.35	0.60	-0.85 to 0.49
Vigorous Activity (min/day)	-1.78	2.87	0.53	-7.37 to 3.82
Sedentary Behavior (episodes/day)	2.31	1.05	0.030	0.23 to 4.40
MVPA Adherence (%)	0.01	0.07	0.90	-0.13 to 0.15

Results of univariate linear regression analysis of preoperative- and postoperative physical activity variables on the outcome Full RTW (in days).

RTW = Return to Work; MET = Metabolic Equivalent of Task; PA = Physical Activity.

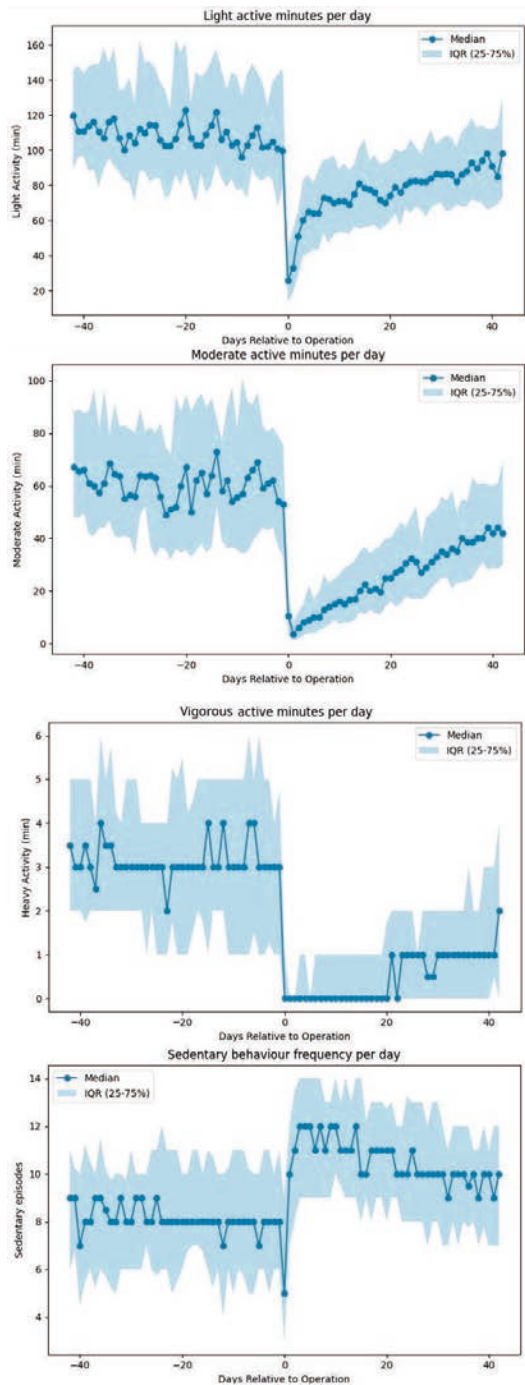


Figure 1. Prospective trends of four physical activity variables (light, moderate, and vigorous activity minutes, and sedentary episodes) from 6 weeks before to 6 weeks after knee arthroplasty among patients participating in the BAAS work-integrated care cohort.

Discussion

Key Results

Our study showed that preoperatively, more vigorous physical activity was associated with delayed full RTW, while more moderate physical activity was associated with earlier full RTW. Although borderline significant, more sedentary episodes preoperatively were associated with earlier full RTW. Postoperatively, more sedentary episodes were associated with delayed full RTW. All other tested associations were non-significant.

To illustrate the effect sizes, associations were scaled to each physical activity variable's IQR: 5 vs. 1 min/day of vigorous activity before surgery (IQR = 4) corresponded to ≈ 17 days longer full RTW; 87 vs. 39 min/day of moderate activity before surgery (IQR = 48) to ≈ 30 days earlier full RTW; 11 vs. 6 sedentary episodes/day before surgery (IQR = 5) corresponded to ≈ 16 days earlier full RTW; and 13 vs. 8 sedentary episodes/day after surgery (IQR = 5) to ≈ 12 days longer full RTW. This underscores that taking into account the actual range in frequency of the physical activity variable provides better insight into the potential clinical relevance than only judging the size of the regression coefficient. These outcomes stress the importance that these physical activity variables surrounding surgery can indeed be of importance to working patients to enhance timely full RTW, and for employers by lowering sick leave costs surrounding KA.^{23,30}

No significant associations were found for pre- or postoperative MET score, light activity or MVPA guideline adherence, nor for other postoperative activity levels.

Interpretation

In our study, postoperative sedentary behaviour was significantly associated with delayed full RTW. This could underscore the need to move regularly during the first six weeks after surgery, ideally every 30 min. This highlights the potential role of physiotherapists in providing structured guidance on interrupting prolonged sedentary episodes and gradually rebuilding activity patterns during the early postoperative phase. Beyond the known health risks of sedentary behaviour, such as higher risk of all-cause mortality and cardiovascular disease, this study adds that it also contributes to a less timely full RTW after KA.¹ Occupational physical therapists could therefore encourage fewer sedentary episodes, especially for desk job workers, by, for example, promoting an under-desk bike when patients RTW after KA.

We also found that higher preoperative levels of moderate activity were associated with earlier full RTW. Patients who are more physically active are generally fitter, and higher preoperative fitness is a known prognostic factor for better recovery after surgery ('better-in, better-out').^{31,32} This may reflect greater functional reserve and movement tolerance, facilitating earlier resumption of work-related tasks. This underscores the importance of being physically active before surgery, not only for physical preparedness but also for postoperative participation.^{33,34} By contrast, preoperative vigorous activity was associated with delayed RTW, while more sedentary episodes related to faster RTW. We hypothesised that this pattern might reflect occupational context, because patients with knee-straining work often RTW later than those without knee-straining work.¹⁵ To explore this hypothesis, we performed a post hoc exploratory analysis examining the correlation between kneestraining work and preoperative vigorous physical activity. This analysis showed no clear relationship between knee-straining work and heavy physical activity before surgery ($r = 0.135$, $p = 0.243$). Unfortunately, since we could not distinguish between physical activity performed during work hours and leisure-time physical activity, future research is needed to further clarify this association.

Although studies on the relation between physical activity and RTW are limited, we are aware of three papers on this topic. One study found no relation between preoperative activity and RTW.¹⁷ However, in their study, physical activity levels were measured using self-reported questionnaires, which might be less reliable.³⁵ Another study indicated that higher physical activity levels one year after surgery are more likely to RTW earlier.⁷ Like our study, Scott et al. found no relation between postoperative activity and RTW after KA.¹⁶ Hopefully, our findings that preoperatively moderate and vigorous physical activity and postoperative sedentary bouts were significantly associated with enhanced or delayed full RTW, add to a better understanding of the role of physical activity as one of the prognostic factors for work participation among patients receiving KA.³⁶

Limitations

Six potential limitations should be considered when interpreting these findings. First, regarding the workers participating in the structured BAAS cohort. As the BAAS pathway was designed and proved effective to reduce time to full RTW and showed a positive return on investment, it likely reduced variability in full RTW durations.^{20,22} This limited variability may have made it more difficult to detect significant associations between physical (in)activity variables and full RTW. The observed associations might therefore be smaller than in populations who did not have an intervention that stimulated both physical activity and full RTW, like the BAAS work-integrated care pathway.

Second, data loss due to non-adherence in accelerometer wear, particularly postoperatively, could have introduced selection bias. The median number of valid accelerometer days rose from 20 preoperatively to 37 postoperatively. This increase probably reflects the fact that, during recovery, patients found the real-time feedback on their mobility more beneficial and were therefore more motivated to keep wearing the sensor. Although strict inclusion criteria limited this bias, nonadherence may have introduced selection effects, as patients who kept wearing the sensor were probably more engaged in their rehabilitation and therefore more active and less sedentary. In addition, short-term behavioural reactivity to wearing an activity monitor has been described in previous studies.³⁷ However, extended wear duration itself does not necessarily alter average activity levels but rather improves measurement reliability.³⁸ Under this assumption, the observed association between sedentary behaviour and delayed full RTW likely remains valid and may even be underestimated. The large dataset (>5700 valid days) further supports confidence in the observed physical activity patterns.

Third, while univariate linear regression was suitable for exploring individual associations between physical activity variables and full RTW, alternative approaches such as compositional data analysis (CoDA) may offer advantages in certain contexts.^{39,40} However, our variables (intensity-based active minutes and sedentary episodes) do not form a closed composition and thus do not meet CoDA assumptions. Although CoDA can be a powerful tool for analysing time-use data, its application is appropriate only when all relevant behaviours are included as proportional parts of a whole.⁴¹ In our case, the structure and granularity of the available data justify the use of univariate models, and allow for precise interpretation of specific behavioural dimensions in relation to RTW. Also, linear regression assumes approximate normality of the residuals rather than of the raw outcome variable itself. Inspection of the residual diagnostics did not indicate major violations of model assumptions. To further evaluate whether the skewed outcome distribution influenced the results, we additionally performed a sensitivity analysis using a log-transformed outcome to account for skewness and potential zero values. This yielded comparable results, with preserved direction and statistical significance of the associations. We therefore concluded that the findings are robust and not dependent on the specified distributional assumption.

Fourth, the PAM device has not been validated for indirect calorimetry, the gold standard for determining METs, which may cause imprecision at higher intensities. However, Valkenet et al. demonstrated strong agreement between the PAM AM400 and ActiGraph data, supported by high ICCs, indicating acceptable

validity for use in clinical research.²⁶ Also, the PAM defines vigorous activity as >7 METs, while the WHO uses >6 METs.¹ This discrepancy may have underestimated vigorous activity and overestimated moderate activity in our study compared to WHO standards. Consequently, caution is warranted when comparing our results to studies or guidelines that apply the lower threshold.

Fifth, the Dutch guideline for physical activity consists of two parts: a minimum of 150 min a week of at least an intensity of moderate physical activity minutes, and at least two times a week, muscle strength exercises.²⁹ We only used the first part of this guideline by monitoring at least an intensity of moderate physical activity.

Finally, the observational nature of this study precludes causal inference; it remains unclear whether slower recovery causes inactivity or vice versa. Still, this study provides important exploratory insight into real-world associations that can inform hypotheses and design choices for future intervention studies. Moreover, RTW is a complex multidimensional construct. Future research should incorporate other evidence-based prognostic factors for RTW such as preoperative sick leave, the physical demands of the patient's occupation, patient expectations and the type of surgery.³⁶ Similarly, socioeconomic compensation systems for sick leave should also be taken into account.⁴²

Taken together, these limitations highlight the complexity of studying physical behaviour in real-world recovery settings, while the scale and granularity of our data provide a solid foundation for interpreting the key findings.

Generalizability

The generalizability of the present findings is likely not limited to Dutch working-age patients having KA within the BAAS work-integrated perioperative care cohort. The multicenter design, inclusion of 121 patients, and consistent use of validated activity measures enhance generalizability to other workers receiving KA in and outside the Netherlands. However, caution is warranted when extrapolating these findings to populations receiving other (orthopedic) types of surgery, to non-working or older adults, or to contexts without coordinated perioperative work-guidance. Additionally, social security systems vary substantially across countries and health systems, which may influence RTW trajectories. Future research should replicate these findings across more diverse musculoskeletal surgeries and social security systems to further strengthen external validity.

Conclusion

This hypothesis-generating study shows a nuanced relationship between physical (in)activity and full RTW following KA. Preoperative moderate-intensity physical activity was associated with earlier full RTW, while both preoperative vigorous physical activity and postoperative sedentary behavior were associated with delayed full RTW. No significant associations were found for pre- or postoperative MET score, light activity, or MVPA guideline adherence, nor for other postoperative activity levels. These findings suggest that balanced physical activity counseling, tailored to recovery stage, may be valuable in optimizing postoperative work participation. Future research should further clarify how occupational context interacts with physical activity in relation to RTW.

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Conflict of interest

The authors have no relevant financial or non-financial interests to disclose.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of University of Amsterdam (28/10/2021, reference W21_454 # 21.504). Informed consent was obtained from all individual participants included in the study.

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CHAPTER

10

General discussion and
future perspectives

General discussion

The aim of this thesis was to examine whether hospital-led, work-integrated care can move perioperative practice beyond its traditional focus on pain, mobility, and implant survival toward the broader goal of social participation. Because no evidence-based pathway for return to work after knee arthroplasty existed, the Back At work After Surgery (BAAS) work-integrated hospital-led pathway was designed and evaluated step by step. This work addressed four aims: (1) to establish the feasibility of BAAS in routine care (Chapters 2–3); (2) to test its effectiveness against care-as-usual (Chapters 4–5); (3) to assess its economic impact and return on investment (Chapters 4 and 6); and (4) to identify determinants that could further optimize the hospital-led BAAS work-integrated pathway (Chapters 7–9). The principal findings for each of these four aims are summarized in the Main findings section. Their broader meaning is discussed in the Interpretation of findings section, followed by the Methodological considerations section. Recommendations for future research are then presented, followed by the Implications and recommendations for practice section. Finally, the Conclusions section provides the overall conclusions of this thesis.

Main findings

Aim 1 – Feasibility of BAAS (Chapters 2 and 3)

Across eleven years, the orthopedic ward of Nij Smellinghe hospital sequentially implemented four peri-operative pathways, from Joint Care, to a more function-tailored in-hospital recovery approach, to Fast-track optimization, and finally prehabilitation. Each step accelerated in-hospital recovery, reduced length of stay and increased the proportion of home discharges, with diminishing incremental gains suggesting a plateau in short-term ward outcomes. This stepwise transformation demonstrated the organizational feasibility and readiness of a hospital setting to run structured, function-oriented care, an essential precondition for embedding a work-integrated pathway like BAAS (Chapter 2). In the dedicated BAAS feasibility pilot, nearly all scheduled components were delivered as intended; patients evaluated the pathway as helpful, and professionals considered it workable within existing workflows. The primary limitation was reach—38% of invited eligible patients—mainly due to the long travel distance to the hospital for physical therapy (Chapter 3). The identified shortcomings and suggested improvements were addressed in the protocol for evaluating effectiveness and costs.

Aim 2 – Effectiveness of BAAS (Chapters 4 and 5)

The protocol prespecified comparators, endpoints, and analyses, adding a second high-volume hospital, namely ETZ, to implement BAAS and defining the propensity-score matching approach to minimize selection and reporting bias and to enhance generalizability of the BAAS evaluation (Chapter 4).

In the effectiveness study, BAAS accelerated and increased work resumption versus two national care-as-usual cohorts: 27 days to the first day back at work under BAAS versus 52 and 43 days in care-as-usual. Full contractual hours were reached after 183 days in BAAS versus 210 days in care-as-usual. At 1 year, 2% of BAAS participants were not yet back on contract hours versus 16% and 13% in care-as-usual. Sensitivity analyses showed no difference for time to first work resumption by center, while time to full return to work was significantly faster in Nij Smellinghe hospital compared with hospital ETZ (Chapter 5).

Aim 3 – Economic impact of BAAS (Chapters 4 and 6)

The protocol paper also predefined the economic evaluation, perspectives, and cost components to ensure transparent and comparable resource accounting alongside effectiveness (Chapter 4).

Implementing BAAS entailed € 845 per patient (workplace assessment, accelerometer package, case-management time). Over twelve months, BAAS patients accrued € 7 263 lower productivity loss from absenteeism and € 489 lower primary-care costs than matched controls; secondary-care and presenteeism costs showed no meaningful differences. Net savings were € 4 493 (employer perspective) and € 4 982 (societal perspective), yielding returns on investment of 532% and 590%, respectively, both of which were statistically significant (Chapter 6).

Aim 4 – Determinants to improve and personalize BAAS (Chapters 7-9)

A protocol for a prognostic review was published (PICOTS framework, multi-database search, QUIPS risk-of-bias assessment, and GRADE certainty appraisal) to synthesize evidence on preoperative prognostic factors for return to work, including physical work demands, type of arthroplasty, preoperative sick leave and patients' expectations regarding recovery (Chapter 7).

In line with the objective to optimize participation-oriented care, the systematic review demonstrated that physical work demands, type of arthroplasty, preoperative sick leave, and patients' expectations regarding recovery are

relevant prognostic factors for return to work, although the certainty of evidence varied across factors and outcomes (Chapter 8).

In addition, more postoperative sedentary episodes were associated with delayed full return to work, suggesting that early behavioral recovery patterns may signal participation outcomes beyond traditional clinical indicators (Chapter 9).

Interpretation of findings

To interpret the findings of this thesis, four topics are addressed. First, the observed effects are scaled to the Dutch working-age knee arthroplasty population to illustrate potential societal and economic impact. Second, the results are situated alongside other work-integrated care studies surrounding surgery. Third, the defining features of “work-integrated care” are outlined. Fourth, the translation of the work-integrated pathway from research to care-as-usual is explored, based on literature that identifies key success factors for implementation in healthcare.

The first topic concerns the potential national implications of our findings. Scaling our observed BAAS effects to the Dutch working-age knee arthroplasty volume in 2024 (TKA = 10,715; UKA = 4,750; total = 15,465) and applying a simple per-patient multiplication (no additional modeling), nationwide delivery of the BAAS pathway would advance the first day back at work by 16–25 days, equivalent to approximately 247,000–387,000 calendar-days gained, and bring full return to work forward by about 27 days ($\approx$ 418,000 calendar-days) (LROI, data delivered upon request). In addition, an estimated 1,700–2,165 more individuals would be fully working within 12 months (98% under BAAS vs 84%–87% under care-as-usual; Chapter 5). From an economic standpoint (Chapter 6), the per-patient net benefit of €4,493 (employer perspective) and €4,982 (societal perspective) implies cohort-level net gains of roughly €69.5 million and €77.0 million, respectively. These back-of-the-envelope estimates do not include important metrics such as the number of working-age people who are currently not employed. Nevertheless, they suggest that, if adopted at scale, BAAS could deliver substantial labor-market and macroeconomic value.

The second topic is to situate the BAAS work-integrated pathway within the emerging work-integrated care literature. Since Coenen’s 2020 review reported insufficient and inconsistent evidence for integrated care in orthopedic surgery with respect to sport and work participation—and called for higher-quality studies, several hospital-led work-integrated pathways have appeared.¹ In

Finland, the Coordinated Return to Work model has been evaluated in both a multi-district register study and a prospective cohort: together, these studies reported shorter sickness-absence periods after knee (−14.4 days, 95% CI 7.5–21.3) and hip arthroplasty (−9.1 days, 95% CI 4.1–14.1), mean return to work times of 69 days (THA) and 87 days (knee arthroplasty), and workplace adjustments in more than half of patients while consistently highlighting expectations and pre-operative sick leave as key prognostic factors.^{2,3} In the UK, the OPAL program mapped highly heterogeneous return to work advice and designed an occupational-advice intervention embedded in surgical pathways, underscoring the need for structured, work-focused care (with a comprehensive HTA describing development, components and work-related outcomes).⁴ This intervention has not been tested for effectiveness to date.

In oncology, a multicenter RCT among patients with gastrointestinal cancer tested early, tailored, hospital-based work support delivered by oncology nurses and oncological occupational physicians; although underpowered, it suggested fewer days to return to work (median 190 vs 233; log-rank $p=0.37$), higher 12-month proportion of return to work (83.3% vs 73.5%), and fewer work limitations at 3 months.⁵ Belgian groups have moved the agenda forward in spine populations in three complementary ways: a 2025 systematic review on post-surgical chronic spinal pain concludes that, while the overall certainty is low, the most promising approach for improving work participation is personalized, work-integrated, multidisciplinary rehabilitation.⁶ In a study after lumbar fusion (REACT), a coordinated pathway yielded greater improvements in disability and back pain and higher 12-month return-to-work rates (88% vs 56%) than care-as-usual.⁷ Finally, the OPERA multicenter RCT protocol specifies personalized biopsychosocial program that targets work ability as the primary endpoint. The effectiveness of this work-integrated program is not published yet.⁸

The increase in studies designing or evaluating work-integrated care surrounding surgery is an important and much needed development. However, three recurring methodological issues need to be addressed for these work-integrated care studies. First, many studies report time to any return to work or days of sickness absence as outcome measures, whereas full return to work and 12-month proportions are less consistently reported, and formal economic evaluations remain comparatively uncommon in peri-operative settings.^{2,3} The emerging Core Outcome Set for Work participation (COS-Work) reports that as a minimum, trials should report one employment outcome and two RTW outcomes (proportion returned and time to start and full return to work). Second, many programs did not undertake an upfront feasibility study. This might have contributed to less

clear primary outcomes (e.g., privileging any return to work over full return to work), avoidable recruitment and data-collection issues, uncertainty about acceptability and fidelity, and imprecise inputs for sample-size and economic analyses.⁹ Third, none of these studies included cost analyses. The BAAS pathway contributes to the current evidence by addressing these three issues.

The third topic is clarifying what qualifies as work-integrated care, and thereby hopefully stimulating other hospital-based initiatives. In Kluit's scoping review, hospital-led work-integrated care is defined broadly as hospital care that pays explicit attention to work participation.¹⁰ Practices range from merely recording a patient's occupation or offering generic advice to more extensive collaboration with patients and other professionals, and the review notes substantial variation and a paucity of usable medical guidelines, i.e., the label is permissive and often under-specified.¹⁰ Against that baseline, the hospital-embedded programs discussed in this paragraph meet—and typically exceed—this minimal threshold: they not only “attend to work,” but also embed procedures for workplace coordination and job-focused adjustment^{2,3}, or formally design pathway-integrated occupational advice⁴, and in some cases combine graded activity with a coordinated workplace intervention within clinical care.¹¹

These signals, together with the medical guideline and user perspectives, point toward a tighter, operational definition of hospital-embedded work-integrated care^{12,13}. The Dutch guideline module for medical-specialist care recommends making work an explicit treatment goal in routine consultations and organizing low-threshold collaboration with occupational physicians (e.g., arranged joint contacts when indicated), thereby moving beyond nomenclature toward concrete collaboration routines.¹² From the patient side, a qualitative evidence synthesis identifies four needs that “true” hospital-embedded work-integrated care should meet: substantive work-focused guidance, a structured and continuous process, a supportive professional stance, and tailored delivery—again implying an organized workflow rather than intent alone.¹³ Evidence syntheses in common mental disorders similarly indicate that workplace-involving, team-based, work-directed components can increase or accelerate return to work, reinforcing the need for defined interfaces with the employer/occupational health side.¹³ Finally, outcome selection should follow the Core Outcome Set—at minimum, one employment outcome plus two return to work outcomes (proportion returned and time to start and full return to work), and, where feasible, outcomes that enable economic evaluation.¹⁴

Taken together, a practice-ready definition would specify that hospital-based hospital-embedded work-integrated care (a) sets work as an explicit treatment objective; (b) embeds timed, documented routines for collaboration with occupational/employee stakeholders (e.g., workplace assessment and arranged joint contact with the occupational physician around the first return to work attempt); (c) delivers a tailored, graded return to work plan matched to job demands; and (d) evaluates outcomes with the Core Outcome Set - Work and, ideally, a full economic analysis.¹⁴ In this narrower, operational sense, BAAS fits—and goes further: it combines an explicit work goal with early workplace assessment and a graded plan; it schedules a structured joint consultation around the first return to work attempt that includes the patient, the occupational physician, an occupational expert and two physical therapists (treating and hospital-based); and it tracks both proportion of and time to start and full return to work.

The fourth topic is the translation from research to care-as-usual in work-integrated pathways. Despite the growing evidence for the effectiveness of work-integrated care surrounding surgeries, and the adoption of return to work as an outcome in clinical guidelines, evidence of work-integrated pathways implemented in care-as-usual is scarce.¹² The aforementioned CRTW study, however, seems to be implemented in usual care as a part of statutory occupational health care.² This is not surprising, given the low rate at which proven interventions are successfully implemented and the long time lags commonly observed in translational research.^{15,16} In contrast, the BAAS work-integrated pathway was not only shown to be feasible, effective, and economically attractive, but was also implemented as care-as-usual at Nij Smellinghe Hospital within one year after completion of the effectiveness study. By the time this thesis was written (April 2026), 156 patients had been offered participation in BAAS. Of these, 99 were willing to participate (63%), while 57 declined. Among employers, 25 agreed, 50 declined, and 24 decisions were still pending.

Why does hospital Nij Smellinghe, then, succeed in moving from research to care-as-usual so quickly? Implementation science frameworks and reviews consistently identify several interacting domains that may influence whether complex interventions become successfully embedded into routine care. Rather than representing necessary and sufficient conditions, these domains provide an explanatory lens to understand implementation processes in practice. Based on implementation reviews, four particularly relevant domains can be distinguished: (1) Inner setting & implementation climate; (2) Implementable intervention design; (3) Pragmatic, multi-component strategies; (4) Early implementation

outcomes.¹⁷⁻¹⁹ At hospital Nij Smellinghe, the BAAS work-integrated pathway meets these four ingredients:

1. Inner setting & implementation climate: The development of the BAAS work-integrated pathway has its roots in an important collaboration of different stakeholders who understand the importance of translation from research to practice. For example, the collaboration started between an occupational insurance company and hospital Nij Smellinghe, combining insights from medical and occupational care. Also, within hospital Nij Smellinghe, BAAS is owned across the organization, from physical therapists and nurses to management and the board, and, since BAAS started, participation-integrated care has been written into the hospital strategy²⁰; BAAS is also highlighted by federation of general hospitals (Samenwerkende Algemene Ziekenhuizen; SAZ) as an exemplar for innovative and strategic care.²¹
2. Implementable intervention design: The research team included professionals from occupational health, rehabilitation and pain medicine, orthopedic surgery, and physical therapy, affiliated with three university hospitals in the Netherlands. This multidisciplinary composition ensured that the BAAS pathway was designed from multiple relevant perspectives and strengthened its implementability. This collaboration was made possible through funding from ZonMW to study the effectiveness and return on investment of BAAS.²² Especially, BAAS uses clear, timed routines (pre-operative consult; an interdisciplinary meeting around week 5 with all stakeholders; a 6-week visit; and three-monthly follow-ups), an explicit work goal with a graded return to work plan, and structured coordination; these elements are standardized and recorded in the electronic health records so teams know who does what, when (Chapter 4).
3. Pragmatic, multi-component strategies: Rather than a heavy pre-launch training, the principal investigator acted as an embedded implementer and coached peers in a practice-based learning environment; the prior feasibility phase served as a rehearsal that surfaced issues early and enabled rapid fixes (Chapter 3-6). In addition, the pragmatic solution of invoicing employers contributed to the economic viability of the pathway. Lastly, the insurance company and the research team were closely involved in designing strategies to implement BAAS as care-as-usual.

4. Early implementation outcomes: The feasibility work, made possible through funding from an insurance company, explicitly addressed acceptability, feasibility, and fidelity before scale-up, and routine electronic health record documentation supports reliable delivery, spread, and maintenance in care-as-usual (Chapter 3).

Taken together, the collaboration between a regional hospital, experts from different fields, and an insurance company helped build a participation-first strategy at Nij Smellinghe Hospital. Combined with an implementable pathway design, embedded facilitation during rollout, and early attention to implementation outcomes, this aligns closely with factors identified in implementation reviews and helps explain the unusually short BAAS research-to-routine trajectory. At the same time, these four domains do not fully explain implementation success. The sensitivity analyses in Chapter 5 suggested better outcomes in Nij Smellinghe than in ETZ, which may partly reflect differences in how implementation was supported. In ETZ, implementation mainly consisted of a one-day training and biweekly telephone contact — possibly too little to build the same local ownership, routine, and interdisciplinary coordination as in Nij Smellinghe. This underlines that transferring a complex intervention across hospitals is not just a matter of protocol transfer.

Methodological considerations

The development, evaluation, and implementation of the BAAS work-integrated pathway were investigated throughout this thesis using a diverse methodological toolkit: (i) a large-scale quantitative database analysis (Chapter 2); (ii) a mixed-methods feasibility pilot (Chapter 3); (iii) a preregistered multicenter study protocol (Chapter 4); (iv) an effectiveness study using inverse probability of treatment weighting alongside matched cost-effectiveness analyses (Chapters 5–6); and (v) a systematic review of prognostic factors (Chapters 7–8). This chapter critically discusses the methodological assumptions, strengths, and limitations inherent in each of these approaches.

The study in chapter 2 used a retrospective single-center cohort design to evaluate stepwise care innovations over an 11-year period. This approach was chosen to capture real-world effects of bundled perioperative changes in a naturalistic hospital setting, where randomized trials would be impractical or ethically challenging. Well-conducted observational studies can provide credible and clinically relevant evidence, particularly when based on complete and

consistent electronic health record data.²³ The single-center design strengthened internal consistency by promoting uniform protocol delivery and limiting variation related to inter-institutional differences, which is advantageous when evaluating longitudinal care transformation. However, single-center studies may be less representative of broader clinical variation and may yield less generalizable findings for hospitals with different case-mix, infrastructure, or staffing models.^{24,25} Aggregating implementation into four time periods reflected the way care evolved organically in practice. Although simultaneous introduction of multiple components limits causal attribution, the design allowed us to observe their combined effect under routine clinical conditions. Multivariable adjustments addressed known confounders, though residual bias cannot be ruled out. Overall, this approach offered a pragmatic and internally consistent foundation to inform more controlled studies later in the thesis.

The study in chapter 3 applied a single-center mixed-methods feasibility design to examine the practical implementation of the BAAS work-integrated pathway following knee arthroplasty. The use of mixed methods was important because it captured both measurable aspects of intervention fidelity and the experiential perspectives of patients and professionals. In retrospect, it would have been preferable to conduct the study at both Elisabeth-TweeSteden Hospital and Nij Smellinghe Hospital, rather than only at Nij Smellinghe. This combination would have enabled a nuanced understanding of where implementation issues arose, why these issues emerged, and how they could be resolved. As highlighted in the Medical Research Council guidance on developing complex interventions, such integration of qualitative and quantitative insights is critical for identifying uncertainties in delivery and tailoring the intervention to its context.²⁶ In this study, the findings directly informed protocol improvements, such as refining the timing of patient education, enhancing team communication, and embedding individualized work-related goal setting, prior to initiating the multicenter study protocol described in Chapter 4. The feasibility phase thus provided not only proof of operational viability but also actionable knowledge that strengthened the intervention's contextual fit and delivery. The reach was low (38%), largely because travel to the hospital posed a barrier. Therefore, a key improvement was to shift rehabilitation physical therapy to primary-care settings rather than hospital-based services (Chapter 3).

The study in chapter 5 evaluated the hospital-led BAAS work-integrated pathway using a non-randomized, comparative-effectiveness design across three real-world cohorts. In occupational health, and especially for multicomponent, workplace-integrated return-to-work programs, randomized trials are often

not the most feasible or informative option: organizations may resist random allocation, contamination between arms is likely, blinding is impossible, and the small number of eligible clusters limits power; in these contexts, strong quasi-experimental and observational designs are explicitly recommended.²⁷⁻²⁹ Consistent with this guidance and our preregistered protocol (Chapter 4), we used inverse probability of treatment weighting to balance measured confounders while retaining sample size; propensity score matching was deliberately avoided in Chapter 5 to prevent loss of precision. Alternative experimental designs (e.g., cluster or stepped-wedge randomized trials) would have required many clusters and prolonged staged roll-out to achieve adequate power and reduce bias—conditions that did not align with service-level implementation and routine delivery.²⁸ We acknowledge that unmeasured confounding cannot be ruled out; however, convergent findings across multiple return to work endpoints and sensitivity analyses (Chapter 5) strengthen causal inference and are in line with recommended practice for evaluating complex occupational interventions when randomization is impractical.^{27,29} Moreover, both care-as-usual cohorts were drawn from hospitals with an above-average focus on work participation, likely biasing results toward the null and thus underestimating the effect of the BAAS pathway.

The study in chapter 6 presented a return on investment analysis of the hospital-led BAAS work-integrated pathway using a matched cohort design. In contrast to Chapter 5, where IPTW was applied to preserve statistical power, this chapter used one-on-one propensity score matching to improve internal validity and enhance comparability of costs and outcomes across groups. Although matching reduced the sample size, it enabled a more robust economic evaluation by minimizing residual confounding. A key limitation, however, is that, unlike the effectiveness study in Chapter 5 which contrasted BAAS with two national care-as-usual cohorts, the economic evaluation compared BAAS with only one care-as-usual cohort; this narrower comparator set may limit precision and external comparability of cost and effect differences. Moreover, because both BAAS and control cohorts were recruited in the context of ongoing research on work participation, attention to work may have been higher than in routine practice in both groups; such co-intervention tends to bias effects toward the null, implying that our return on investment estimates could be conservative rather than inflated. The analysis followed best practices for health economic evaluations and was performed from both societal and employer perspectives.³⁰ Preregistration of the analysis plan and adherence to the published protocol (Chapter 4) minimized reporting bias. Internationally, comparable work-integrated arthroplasty interventions exist, most prominently the OPAL-program from the United Kingdom developed for hip/

knee replacement and now under evaluation for clinical and cost effectiveness, but published employer- or societal-perspective return on investment estimates remain scarce; this underscores the relevance of our economic findings while also highlighting the need for confirmatory evaluations in other settings.^{4,31} This methodological approach allowed a transparent and policy-relevant assessment, showing that BAAS delivered superior outcomes at substantially lower societal cost with a positive return on investment. Additionally, broader international data on productivity loss after surgery, showing particularly high absenteeism costs for total knee replacement, support the policy salience of focusing on return to work in this population.³²

In Chapter 8, the systematic review on prognostic factors for return to work after knee arthroplasty adhered to a pre-registered Cochrane protocol, ensuring methodological rigor and transparency throughout the review process. This approach provided a comprehensive synthesis of evidence regarding key prognostic factors, including physical work demands, type of arthroplasty, preoperative sick leave, and patient expectations. Although the Cochrane framework is known for its methodological rigor, an important limitation of this review, as noted in the Chapter 7 protocol, is its reliance on observational studies. Heterogeneity in outcome definitions and the potential for residual confounding across studies may have reduced the certainty of the pooled findings, particularly in prognostic evidence derived from non-randomized studies.^{33,34} Variation in study quality may also have introduced bias affecting the interpretation of the results, underscoring the importance of structured risk-of-bias assessment in prognostic factor research.³⁵ Nonetheless, by mapping the identified factors within the WHO-ICF framework, this review offers useful direction for future work-integrated care strategies and highlights the need for further research to reduce uncertainty and support clinical application.²⁶

The study in Chapter 9 employed a hypothesis-generating design, using a prospective cohort to explore associations between pre- and postoperative physical activity levels and return to work. Due to the observational nature of the study, causal inferences cannot be drawn, and the results should be viewed as associative. The use of univariate regression models was appropriate for this exploratory analysis, but potential confounders were not fully accounted for, limiting the ability to draw definitive conclusions. Additionally, non-adherence to accelerometer wear may have introduced selection bias, as more engaged patients were more likely to wear the device, potentially skewing the results. Compositional Data Analysis (CoDA) could have provided a more integrated analysis of physical activity patterns, but the data structure did not meet CoDA

assumptions.³⁶ Despite these limitations, the study provides valuable insights into the role of postoperative sedentary behavior in delayed RTW.

Recommendations for future research

Future research should address multiple complementary directions to further advance participation-oriented hospital care. Building on the findings of this thesis, we propose four key domains that warrant further exploration. First, research is needed to expand and scale the BAAS work-integrated pathway to other clinics and hospitals, patient populations, and surgical procedures. Second, studies should aim to bridge the gap between health care and occupational participation, for example by structurally incorporating work-related outcomes into national clinical registries and by studying sustainable financing, employer willingness to pay, and equitable access to work-integrated care. Third, future research should further examine the role of physical activity and sedentary behavior in recovery and return to work after surgery, and should evaluate whether accelerometer-based activity monitoring, when combined with feedback and coaching, can contribute to improved recovery behavior and sustainable work participation. Finally, economic and societal valuation of participation-integrated care deserves increased attention, including cost-effectiveness analyses and research into health equity and access. Together, these domains provide a comprehensive research agenda that supports a gradual shift toward care models that align more closely with patients' everyday lives and societal roles, and the economic and societal value of health care for the Dutch economy. After all, changes to better care take time, and come step-by-step as demonstrated in this thesis (chapter 2).

Expanding and scaling the BAAS work-integrated pathway in practice

While this thesis demonstrated the effectiveness of the hospital-led BAAS work-integrated pathway in workers receiving knee arthroplasty, return to work is likewise challenging after other orthopedic procedures—for example after arthroscopic rotator cuff repair (73% returned to previous work), after surgery for cervical radiculopathy (~50% by four months; 72% by three years), and after proximal interphalangeal joint arthroplasty (88% within twelve months).³⁷⁻³⁹ Qualitatively, a multi-stakeholder study also highlighted that patients miss structured, hospital-led work-integrated care.⁴⁰ These patterns suggest that the BAAS principles, early personalized goal setting, timely interdisciplinary care, tailored rehabilitation, and workplace guidance, may generalize to other surgical contexts. Beyond surgery, adding occupational care to chronic low-back-

pain treatment reduced time to return to work by approximately 120 days in the Netherlands: 88 days versus usual-care 208.¹¹ Tilburg University is focusing on patients' goals during return to work after traumatic injuries in the We Care program.⁴¹ Future research should therefore assess the feasibility and (cost) effectiveness of BAAS-like pathways in other high-impact surgeries, focusing on clinical recovery as well as sustainable work participation. In addition, research should examine how such pathways can be successfully transferred across hospitals with different organizational contexts, as experiences within this thesis suggest that implementation success may depend not only on the pathway itself, but also on local ownership, implementation climate, implementation support, and early monitoring of implementation outcomes. Promising examples within and beyond orthopedics are OPAL, REACT, CRTW and GIRONA.^{2-5,7}

Although the BAAS work-integrated pathway has demonstrated favorable return to work and return on investment outcomes within the first postoperative year, Dutch occupational legislation makes the two-year horizon critical. Under the Gatekeeper Improvement Act, employees and employers have 104 weeks to achieve sustainable reintegration before a legally mandated process begins to seek suitable work outside the original organization and before the worker may eventually transition to long-term disability or unemployment benefits (WIA/WW). In practice, orientation toward this process often starts around 52 weeks, which can prematurely narrow attention toward external job placement and shift focus away from consolidating sustained return to the original role; employers' wage-continuation obligations also end at 104 weeks. Future research should therefore extend follow-up to at least 24 months to assess whether the BAAS work-integrated pathway sustains its early gains in work participation and societal return on investment across the full statutory window. This focus is essential, because recent evidence indicates that once workers enter long-term disability, interventions such as knee arthroplasty rarely restore work participation, and even among those who return, longer-term employment retention can be jeopardized, especially in physically demanding jobs.^{42,43}

Bridging surgical care and occupational participation

Within orthopedics, structural integration of work participation into routine care is gaining momentum. In the Netherlands, the Dutch National Registry for Orthopedic Interventions (LROI) is piloting the registration of return to work as a care-as-usual outcome, which would make monitoring work participation as routine as tracking complications.⁴⁴ To accelerate this shift nationally, a competitive grant from the Occupational Assessors Knowledge Center (AKC) was given to develop and evaluate Pre-WERK (Prevention at Work Evaluation Recovery Kit).⁴⁵

The project will co-develop a practical tool that brings occupational assessors into the perioperative trajectory before the conventional 52-week review and will assess its feasibility and planned integration into the BAAS work-integrated pathway. This tool will consist of three elements: first, a route map for the patient to outline the different steps in occupational and medical care, including a list of contact details for all involved professionals. Second, an information page for the occupational assessor to inform him or her about possible limiting or beneficial factors for return to work after surgery. Third, a form in which the occupational assessor can produce a structured report of limiting and beneficial factors regarding return to work. Outside the Netherlands, two interventions illustrate what system-level integration can deliver. In Finland, the Coordinated Return to Work model, direct referral from hospital to occupational health care using the same electronic patient file, has shown shorter time to return to work in a one-year prospective cohort study after hip and knee arthroplasty and reductions in sickness-absence duration around implementation in a nationwide register.^{2,3} These examples echo the call from a recent review, evaluating 50 years of research on this theme, to adopt whole-system, participation-oriented approaches that explicitly bridge healthcare and the workplace.⁴⁶

Finally, because work-integrated care is not part of insured medical care in the Netherlands, the occupational components of the BAAS work-integrated pathway are currently financed through a direct employer contribution. In practice at Nij Smellinghe, employers receive an information letter and quotation for a fixed co-payment that covers the occupational assessment, coordination elements of the pathway and future research for BAAS, after consent of the involved patient. Future research should assess employers' willingness to pay for work-integrated health care, especially the affordability for small- and medium-sized enterprises, and whether such co-financing enhances the long-term sustainability of implementing the BAAS work-integrated pathway at scale and maintaining embedded research. This approach aligns with the Dutch Social and Economic Council's call to strengthen prevention and tighten the connection between occupational health and regular healthcare⁴⁷, and it is supported by our economic evaluation showing substantial net savings and a positive return on investment from both employer and societal perspectives (Chapter 6).

Physical activity, sedentary behavior, and accelerometer-based activity monitoring

Chapter 9 suggests that perioperative physical activity and sedentary behavior may be relevant for full return to work after knee arthroplasty. However, because the study was observational and hypothesis-generating, these findings should

be interpreted as associative rather than causal. Future research should therefore distinguish between two related but different questions: first, whether physical activity and prolonged sedentary behavior are modifiable determinants of return to work after surgery; and second, whether accelerometer-based activity monitoring, combined with feedback and behavioral coaching, can help patients improve recovery behavior and achieve earlier or more sustainable return to work. In line with broader concerns about reproducibility in health research, these findings require replication across settings, while the specific added value of accelerometer-based monitoring should be tested as an active behavior-change component rather than assumed as a measurement tool alone. Such studies should use designs that allow stronger causal inference, include relevant confounders, and preferably evaluate both activity behavior and participation outcomes over longer follow-up.

Implications and recommendations for practice

This section translates the BAAS care pathway into concrete, role-specific actions to support recovery that includes work and participation. Recovery after hospitalization is a multidimensional process that affects every ICF domain, and timely coordination across settings is essential for return to work and sustained participation.⁴⁸ To keep responsibilities clear and implementation practical, the recommendations are organised into three groups: (1) working patients and their immediate environment, (2) healthcare professionals working in a hospital, and (3) professionals and stakeholders outside the hospital.

1. Patients (workers) and significant others

Recovery may proceed more smoothly when work is included in the conversation from the very start of the care pathway. Early expectation management may be supported by setting a concrete work-related goal, for example by using Goal Attainment Scaling, and by discussing job demands, commuting requirements,

Direct advice for patients and significant others

- ✓ Discuss work before surgery
- ✓ Clarify job demands, commuting, and shift patterns early
- ✓ Arrange, if possible, a preventive consultation with the occupational physician
- ✓ Use activity data, when available, to discuss recovery patterns
- ✓ Encourage graded activity and autonomy
- ✓ Avoid overprotection and unnecessarily discouraging activity

and shift patterns before admission.⁴⁹ In addition, a preoperative consultation with the occupational physician may help to align expectations, timelines, and feasible temporary accommodations.⁵⁰ Planned contacts may also be used to discuss physical activity, prolonged sedentary behavior, and day-to-day recovery patterns. When available and acceptable to patients, accelerometer-based activity monitoring can help make these patterns visible and support shared reflection on recovery behavior; however, its added value as an intervention to improve return to work outcomes should be evaluated in future research. Patients may also benefit from asking whether participation-integrated care is incorporated within the hospital and, where relevant, from choosing hospitals that explicitly provide such care.

Significant others may support recovery by encouraging and normalising graded activity, by providing practical support that promotes autonomy (e.g., transportation to work trials, pacing daily tasks), and by reinforcing realistic expectations about recovery and return to work. By contrast, overprotection and discouragement of activity have been associated with delayed recovery and prolonged sick leave.^{51,52}

2. Hospital-based healthcare professionals and leadership

Medical specialists have an important role within participation-integrated care. Their advice often carries substantial weight for patients. A brief and explicit discussion of meaningful activities, such as work, at the time of indication, documentation of a preliminary work goal in the medical record, and referral to the hospital-based physical therapist for baseline testing and work-specific questionnaires may create early alignment (Chapters 3-6, 8).^{50,53} Coordination with occupational stakeholders may be particularly relevant when job demands are high; BAAS formalises this through early discussion of return to work and active referral to the hospital-based physical therapist (Chapters 3-6). In total knee arthroplasty, consultation alone did not shorten time to return to work, and effects varied according to preoperative expectations⁵⁴, underscoring the importance of expectation-aligned, graded planning rather than referral in isolation.

Hospital-based physical therapists often see clinical care as their primary task. However, rapidly changing clinical care, including shorter lengths of stay and the rise in more chronically ill patients⁵⁵ (Chapter 2), requires a paradigm shift toward participation-centered, cross-continuum practice. In practical terms, this includes setting explicit participation goals, coordinating discharge and follow-up with primary care and occupational health, using behavioral coaching to

support graded activity and reduce prolonged sedentary behavior, and, when available, discussing activity data as part of self-management, and routinely tracking participation outcomes alongside clinical metrics. Within this model, the hospital-based physical therapist moves beyond a primarily bedside-oriented role and takes on functions as recovery coach and care coordinator, thereby helping to ensure that shorter hospital stays translate into sustained recovery at home and at work.

Clinical and operational leadership within hospitals can support participation-oriented care by starting from what matters to patients, such as return to important roles including work, rather than from what the hospital already happens to provide. High-quality clinical care and demonstrable impact on meaningful outcomes, for example earlier and more sustainable return to work, may subsequently support pragmatic financing arrangements such as a modest employer co-payment. In addition, the value of such pathways should not be assessed only through straightforward business cases: high-quality patient care may reduce hidden costs, such as

Direct advice for hospital teams and leadership

- ✓ Discuss work and other meaningful roles at the time of indication
- ✓ Record a preliminary work goal in the medical record
- ✓ Refer early to the hospital-based physical therapist
- ✓ Coordinate with occupational stakeholders when job demands are high
- ✓ Set explicit participation goals and align discharge and follow-up accordingly
- ✓ Use coaching and activity monitoring to support self-management
- ✓ Track participation outcomes alongside clinical outcomes
- ✓ Organise protected time, budget, data support, and clear roles for implementation
- ✓ Embed work resumption explicitly in patient information materials

Direct advice for primary-care and occupational physical therapists

- ✓ Prioritise ADL and gait early, then progress toward work-specific capacities
- ✓ Document essential job demands and coordinate rehabilitation goals and graded duties with the workplace and hospital-based physical therapist
- ✓ Use accelerometer summaries to titrate load, reduce prolonged sedentary bouts, and identify delayed progress early

expenditures related to patient complaint management, and may generate less visible benefits, such as positive publicity that increases patient interest in the hospital. Successful implementation may depend not only on the pathway itself, but also on local ownership, interdisciplinary alignment, implementation support, and early monitoring of implementation outcomes. To sustain and spread such approaches, organisational headroom is required in the form of protected time, budget, data support, and clearly defined roles for development and embedded research. Because regional (general) hospitals provide the majority of care, they should be positioned as primary hubs for practice-based innovation and learning. Work should also be addressed explicitly in patient information materials. Only 18 providers (42%) offered guidance regarding work resumption, and the advice provided ranged widely, from 2 weeks to 4 months, indicating substantial inconsistency in the information given to patients.⁵⁶

3. Professionals and stakeholders outside the hospital

Primary-care physical therapists have a key role in sustaining work-integrated recovery after discharge. Early sessions may appropriately prioritise activities of daily living (ADL) and gait, after which rehabilitation can progress toward the specific capacities required for work, such as lifting, kneeling, overhead tasks, static standing tolerance, and task endurance. Practice guidance emphasises the importance of documenting essential job demands, planning graded or

modified duties, and coordinating with the workplace.⁵⁰ When activity data are available, for example through accelerometer-based activity monitoring, they may help to make physical activity patterns and prolonged sedentary bouts visible and support coaching during rehabilitation; the aim is not merely to promote more movement, but specifically to reduce prolonged sedentary bouts after surgery (Chapter 9). Working from a shared record with the hospital-based physical therapist may help to align Goal Attainment Scaling targets, progression

Direct advice for occupational physicians and assessors

- ✓ Become involved as early as possible, preferably before surgery when sick leave is imminent
- ✓ Align expectations, statutory obligations, and the graded return-to-work plan early in the surgical trajectory
- ✓ Identify and coordinate practical workplace accommodations, such as task modification, phased schedules, or assistive devices
- ✓ Use structured communication and shared documentation to keep the patient, employer, hospital team, and primary-care professionals aligned

criteria, and accommodations, while enabling timely signaling when milestones are not met (Chapter 5). Occupational physical therapists may also contribute importantly to work-directed care: in Finland, more than 1000 occupational physical therapists serve approximately 2 million citizens and play a major role in work-directed care.^{2,3}

Early involvement of occupational physicians, ideally before surgery, may help align expectations, clarify statutory obligations, and anchor a graded return-to-work plan to the surgical trajectory, thereby strengthening work-integrated rehabilitation.⁵⁰ When the original role is not immediately feasible, temporary adjustments in tasks or working hours may help maintain momentum while sustainability is monitored within the Gatekeeper timelines. Evidence from related conditions suggests that early, integrated occupational input can shorten time away from work.¹¹ In practice, however, many occupational physicians, particularly within large occupational health service providers, are difficult to access because an occupational physician is often only assigned after six weeks of sickness absence according to the Dutch Gatekeeper Improvement Act; this conflicts with the possibility of a preventive consultation before or shortly after surgery. This contributed to the finding that only 33% of occupational physicians were involved in our study (Chapter 5). Arrangements that guarantee timely access are therefore warranted, such as contract options for preventive appointments without a sickness-absence trigger, assignment of a named occupational physician at the time of surgical indication, direct contact channels for the hospital-based physical therapist and the employer, and clear reimbursement pathways for preventive consultations. Such arrangements could make it more feasible to anchor the graded return-to-work plan early and prevent avoidable delay (Chapter 3). Given the current shortage of occupational physicians, involvement in work-integrated pathways such as BAAS may also help reduce workload, as part of the guidance is provided by the hospital-based physical therapist. In addition, occupational physicians may benefit from greater training in surgery-specific recovery expectations, for example recovery after knee arthroplasty. One study found that occupational physician involvement was associated with a 14-day delay in return to work, possibly because insufficient knowledge led to overprotective advice to patients.⁵⁴

Occupational assessors may be more effective when involved early, that is, before surgery when sick leave is imminent, rather than only after 52 weeks of sick leave. A concise workplace assessment delivered early may help identify practical solutions such as task rotation, assistive devices, phased schedules, or temporary duty modifications. As noted earlier, the promising Pre-WERK tool may support

such earlier, prevention-focused involvement well before the conventional fifty-two-week checkpoint. The tool standardises intake questions, provides checklists for accommodations, generates brief employer-facing summaries, aligns documentation with the return-to-work metrics used elsewhere in this thesis, and facilitates access to the contact details of the professionals involved in recovery and return to work after surgery. A short report shared through the care record may help ensure that the patient, occupational physician, medical specialist, hospital-based physical therapist, and primary-care physical therapist work from the same plan and have insight into whether accommodations were implemented; where helpful, the economic case presented in this thesis may support employer buy-in (Chapter 6). These recommendations are consistent with international development work emphasising early identification, employer-oriented materials, structured communication, and a designated return-to-work coordinator within the orthopedic team.^{4,31}

Educational institutes for medical specialists, occupational physicians, occupational assessors, and physical therapists should place greater emphasis on interdisciplinary collaboration and on participatory outcomes, such as return to work, as a standard component of curricula. This may help prepare future professionals to address patients' functional and participatory needs jointly and to bridge the gap between clinical recovery and meaningful roles in daily life.

As mentioned earlier, LROI is piloting the registration of return to work as a care-as-usual outcome. The inclusion of participation outcomes alongside clinical metrics in national registries may make progress more visible, including employment status, time to first return, time to sustainable return, and employment retention at twelve to twenty-four months. Standard definitions and privacy-compliant linkage to administrative registers would improve comparability and support policy-level evaluation;

Direct advice for education, registries, and policy

- ✓ Embed interdisciplinary collaboration and return-to-work outcomes as standard components of professional education
- ✓ Include participation outcomes in routine registries alongside clinical metrics, using standardised definitions
- ✓ Align reimbursement and organisational structures with work-oriented, multidisciplinary recovery pathways
- ✓ Support policy-level evaluation through privacy-compliant routine data collection and real-world evidence

this aligns with broader calls to embed work participation in routine quality governance (Chapters 5–6).⁴⁶

Employers may strengthen workplace health by fostering closer collaboration with occupational physicians and occupational health services. They can facilitate a broader role for occupational physicians beyond the consultation room by enabling their presence at the work floor, thereby lowering thresholds for workers to seek contact and improving insight into actual working conditions.

Policy makers have a pivotal role in fostering an environment conducive to work-integrated recovery. Both internationally and in the Netherlands, they can promote the integration of work as a key health outcome, which remains underused in many health systems.

At the international level, policy makers may support guidelines that recognise work participation as a measurable health outcome and incentivise health systems to incorporate this into patient care pathways. This may include integrating participation-focused outcomes into WHO health systems frameworks or advocating standardised approaches to evaluating the economic benefits of work-integrated recovery programmes such as BAAS. Greater alignment of such frameworks across countries could support more robust comparisons and facilitate cross-border learning and implementation.

In the Netherlands, together with healthcare insurance companies, policy makers can facilitate the integration of work-oriented care into standard healthcare provisions by aligning reimbursement systems, such as the DBC (Diagnosis Treatment Combination), with participation outcomes.⁴⁷ Government support for initiatives that integrate occupational health professionals into multidisciplinary healthcare teams may help bridge the gap between clinical recovery and return-to-work goals. In addition, policy makers may consider promoting work-related recovery data as part of national healthcare registries, thereby enabling policy-level evaluation and adjustment based on real-world evidence.⁴⁶ In this way, they may support a shift toward a more comprehensive, patient-centered care system in which work participation is regarded as a central element of health recovery.

Finally, researchers should consider designing studies from the ward and the workplace outward. Embedding evaluation in routine workflows, measuring outcomes that matter to workers (time to first return, sustainable return, employment retention), and co-producing protocols with clinicians, occupational physicians, labour experts, employers, and patient partners may increase the

practical usefulness of evidence at both the bedside and the worksite.^{57,58} Pragmatic and hybrid effectiveness-implementation designs, registry-enabled follow-up, and transparent preregistration (for example, with tools such as PRECIS-2) allow care delivery to continue while knowledge accumulates.⁵⁹⁻⁶¹ Sharing reusable measures and de-identified datasets under robust privacy safeguards may help transform individual projects into a broader learning system.

Direct advice for researchers

- ✓ Design research around real-world hospital and workplace practice, with outcomes that matter to workers
- ✓ Use co-produced, pragmatic studies with routine data and transparent preregistration to support implementation and learning

Conclusions

This thesis examined whether hospital-led, work-integrated care can shift perioperative practice toward social participation by improving return to work after knee arthroplasty. Specifically, it investigated (1) feasibility, (2) effectiveness, (3) economic impact, and (4) contextual factors influencing the BAAS work-integrated pathway. The findings demonstrate that BAAS is feasible, with high fidelity and acceptability in an organization that, over eleven years, has evolved toward function- and participation-oriented care, although further improvement in reach is warranted. Compared with usual care, return to work occurred both earlier and in a larger proportion of patients, for first return as well as full return. Economic evaluation showed that intervention costs were more than offset by reduced absenteeism, resulting in a positive return on investment exceeding 500% from both societal and employer perspectives. While there is room for further optimization, this thesis presents BAAS as an illustrative example of participation-integrated care.

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A p p e n d i x

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English summary
Nederlandse
samenvatting

Transitioning Hospital Care Towards Participation-Integrated Care: Development, Evaluation, and Implementation of the Back At work After Surgery (BAAS) Work-Integrated Pathway as an Illustrative Example

Hospitals have become increasingly effective in delivering medical care. Survival has improved, surgical pathways have become more efficient, and length of hospital stay has decreased. Yet, a hospital admission is not only a medical intervention. It is also a major life event that can disrupt how people function, participate in society, and return to the things that matter to them. Traditional hospital outcomes, such as complications, length of stay, pain, mobility, or implant survival, therefore provide only a partial view of recovery. From the patient's perspective, recovery often means regaining autonomy, resuming valued activities, participating in family and community life, and returning to work. This thesis starts from the premise that hospital care should not only aim for clinical recovery, but should also become more explicitly accountable for participation outcomes after hospital admission.

Participation is a central dimension of health. Within the International Classification of Functioning, Disability and Health, participation refers to involvement in life situations — work, family life, education, leisure, and community roles. Although participation is personal and not always easy to measure uniformly, return to work is a particularly relevant and concrete participation outcome for people of working age. Work provides income, structure, social connection, identity, and a sense of contributing to society. Nevertheless, return to work is rarely embedded as a routine outcome in hospital pathways, clinical registries, or quality systems.

Orthopedic surgery, and knee arthroplasty in particular, illustrates this gap well. Knee arthroplasty is performed in high numbers and increasingly in people of working age. While clinical outcomes after knee arthroplasty are generally favorable, many working patients experience delayed or incomplete return to work. Conventional outcome measures such as pain relief, range of motion, and implant survival say little about whether patients are able to resume their occupational and social roles. This thesis therefore uses knee arthroplasty as an illustrative example to examine whether a hospital-led, work-integrated approach can shift perioperative practice toward participation-integrated care.

The empirical example in this thesis is the Back At work After Surgery (BAAS) work-integrated pathway. BAAS was developed to bridge the gap between medical care and occupational participation for working patients having knee arthroplasty. The pathway is hospital-led and spans the full surgical episode, from

the decision to operate until full return to work. It combines early discussion of return-to-work expectations, baseline functional assessment, work-related goal setting using Goal Attainment Scaling, physical activity monitoring with an accelerometer, occupational assessment, interdisciplinary alignment between medical and occupational professionals, and structured follow-up after surgery. The pathway is built around two core principles: timely integration of medical and occupational care, and active patient participation through personalized goal setting and feedback.

The aim of this thesis was to examine whether BAAS contributes to a deliberate shift — from outcomes that traditionally take center stage in hospital care toward outcomes that matter in patients' real lives. Four questions guided this work: is BAAS deliverable in routine orthopedic practice? Does BAAS improve return to work compared with care-as-usual? What is the economic value and return on investment of BAAS? And which factors help further improve and personalize work-integrated care after knee arthroplasty?

BAAS did not emerge from nothing. Over an eleven-year period, Nij Smellinghe hospital implemented four consecutive care models on its orthopedic ward: Joint Care, Function-tailored care, Fast-track care, and Prehabilitation. Each model was associated with faster inpatient recovery of activities, shorter length of stay, and more frequent discharge to the preoperative living situation — with diminishing gains as the bar was raised. This shows that structured, data-informed care transitions can improve in-hospital recovery, but also that there is a ceiling to what clinically oriented care can achieve. BAAS was the logical next step: shifting focus from what happens during the admission to what matters afterwards.

The feasibility study showed that BAAS could be delivered in routine care. Most pathway components were provided as intended, patients received the planned elements, and both patients and professionals considered the pathway useful and workable. However, reach was limited: 38% of eligible patients participated. The main barrier was the requirement to receive physical therapy at the hospital, which was burdensome for patients living farther away. In addition, only 18% of orthopedic surgeons proactively discussed return to work with patients — a shortcoming that was explicitly addressed in the further development of the pathway. BAAS was therefore acceptable and deliverable, but adaptations were needed to improve accessibility and scalability.

The multicenter effectiveness study showed that patients in the BAAS cohort returned to work earlier and more often than patients receiving care-as-usual. The

median time to the first day back at work was 27 days in BAAS, compared with 52 and 43 days in the two care-as-usual cohorts. Full return to contractual working hours was also reached earlier, with a median of 183 days in BAAS compared with 210 days in care-as-usual. At twelve months, 2% of BAAS participants had not fully returned to work, compared with 16% and 13% in the control cohorts. Notably, some clinical outcomes — such as knee function in activities of daily living — were actually better in the care-as-usual group, while participation outcomes favored BAAS. This shows that clinical recovery and participation recovery are not the same thing — and that optimizing one does not automatically deliver the other.

The economic evaluation showed that BAAS generated positive value. The intervention cost was €845 per patient — comprising the occupational assessment, the accelerometer, coordination by the medical case manager, and a contribution to physical therapy. Over twelve months, BAAS was associated with €7,263 lower absenteeism costs and €489 lower primary-care costs compared with care-as-usual. Secondary-care costs and presenteeism showed no meaningful differences. The net benefits were €4,493 from the employer perspective and €4,982 from the societal perspective, resulting in returns on investment of 532% and 590%, respectively. The implementation costs of BAAS were therefore more than offset by downstream savings, mainly through reduced productivity loss due to absenteeism.

Finally, this thesis explored how work-integrated care after knee arthroplasty could be further improved. A Cochrane prognostic review of 22 studies involving 6,798 participants showed that return to work is influenced by an interplay of clinical, occupational, and personal factors: physical work demands, type of arthroplasty, preoperative sick leave, and patients' expectations regarding recovery. Preoperative sick leave and patient expectations showed the most consistent associations with time to return to work, but certainty of evidence was often low or very low — due to risk of bias, heterogeneity, and inconsistent outcome definitions. Accelerometer data from the BAAS cohort further showed that more preoperative moderate activity was associated with earlier full return to work, while more preoperative vigorous activity and more postoperative sedentary episodes were associated with delayed return. Recovery guidance should therefore not simply focus on moving more, but also on reducing prolonged sedentary behavior after surgery and on individual behavioral recovery patterns.

BAAS offers a concrete example of participation-integrated care: a model in which the hospital does not treat return to work as an external issue, but as a meaningful health outcome that can be discussed, measured, coordinated, and improved. At the same time, implementation remains complex. Reach must be improved, occupational

physicians and employers need to be involved earlier, and the pathway must be adapted for wider use across hospitals, regions, and patient groups.

Perioperative hospital care can reach beyond pain relief, improved mobility, and implant survival — toward outcomes that matter in patients' real lives. The results show that participation-integrated care is not something for the distant future — it works now, in an ordinary regional hospital. The next step is to refine, scale, and evaluate such models across other surgical populations and healthcare systems, so that recovery after hospital admission is judged not only by what happens inside the hospital, but also by whether people are able to resume the roles and activities that give shape to their lives.

Ziekenhuiszorg transformeren naar participatiegeïntegreerde zorg: ontwikkeling, evaluatie en implementatie van het Back At work After Surgery (BAAS) werkgeïntegreerde zorgpad als illustratief voorbeeld

Ziekenhuizen zijn steeds beter geworden in het leveren van medische zorg. Overleving is verbeterd, chirurgische zorgpaden zijn efficiënter geworden en patiënten liggen korter in het ziekenhuis. Toch is een ziekenhuisopname meer dan een medische ingreep. Het is ook een ingrijpende gebeurtenis die van invloed kan zijn op hoe mensen functioneren, deelnemen aan de maatschappijen terugkeren naar de dingen die er voor hen toe doen. Traditionele uitkomstmaten als complicaties, opnameduur, pijn, mobiliteit of implantaatoverleving geven daarmee slechts een gedeeltelijk beeld van herstel. Vanuit het perspectief van patiënten betekent herstel vaak: weer zelf de regie hebben, betekenisvolle activiteiten oppakken, meedoen in gezin en samenleving, en terugkeren naar werk. Dit proefschrift vertrekt vanuit de gedachte dat ziekenhuiszorg zich niet alleen moet richten op klinisch herstel, maar ook nadrukkelijker verantwoordelijkheid moet nemen voor participatie-uitkomsten na een opname.

Participatie is een centrale dimensie van gezondheid. Binnen de International Classification of Functioning, Disability and Health verwijst participatie naar betrokkenheid in levenssituaties — werk, gezinsleven, onderwijs, vrije tijd en maatschappelijke rollen. Hoewel participatie per persoon verschilt en niet altijd eenvoudig meetbaar is, vormt terugkeer naar werk voor mensen in de werkende leeftijd een bijzonder relevante en concrete uitkomst. Werk biedt inkomen, structuur, sociale verbinding, identiteit en het gevoel ergens aan bij te dragen. Toch is terugkeer naar werk zelden ingebed als vaste uitkomst in ziekenhuiszorgpaden, klinische registraties of kwaliteitssystemen.

Orthopedische chirurgie, en knieprothesechirurgie in het bijzonder, laat deze kloof goed zien. Knieprotheseoperaties worden in grote aantallen uitgevoerd en steeds vaker bij mensen die nog werken. Hoewel de klinische uitkomsten doorgaans gunstig zijn, lukt het veel werkende patiënten niet om vlot en volledig terug te keren naar werk. Gangbare uitkomstmaten als pijnvermindering, bewegingsuitslag en implantaatoverleving zeggen weinig over de vraag of iemand zijn of haar werkende en sociale rollen weer kan invullen. Dit proefschrift gebruikt zorg rondom een knieprotheseoperatie daarom als voorbeeld om te onderzoeken of een ziekenhuisgeleide, werkgeïntegreerde aanpak de perioperatieve praktijk kan verschuiven richting participatiegeïntegreerde zorg.

Het concrete voorbeeld in dit proefschrift is het Back At work After Surgery (BAAS) werkgeïntegreerde zorgpad. BAAS is ontwikkeld om de afstand tussen medische zorg en arbeidsparticipatie te overbruggen voor werkende patiënten die een knieprothese krijgen. Het zorgpad wordt vanuit het ziekenhuis aangeboden en beslaat het volledige chirurgische traject — van het besluit tot opereren tot de volledige terugkeer naar werk. Het combineert vroege bespreking van verwachtingen rond terugkeer naar werk, een functionele basismeting, werkgerelateerde doelstelling via Goal Attainment Scaling, monitoring van fysieke activiteit met een accelerometer, arbeidsdeskundige beoordeling, interdisciplinaire afstemming tussen medische en arbeidsgerichte professionals, en gestructureerde follow-up na de operatie. Het zorgpad is gebouwd op twee principes: tijdige integratie van medische en arbeidsgerichte zorg, en actieve betrokkenheid van de patiënt via persoonlijke doelen en feedback.

Het doel van dit proefschrift was te onderzoeken of BAAS bijdraagt aan een bewuste verschuiving — van uitkomsten die traditioneel centraal staan in ziekenhuiszorg naar uitkomsten die er in het echte leven van patiënten toe doen. Vier vragen stonden daarbij centraal: is BAAS uitvoerbaar in de reguliere orthopedische praktijk? Verbetert BAAS de terugkeer naar werk ten opzichte van gebruikelijke zorg? Wat is de economische waarde en het rendement op investering van BAAS? En welke factoren helpen werkgeïntegreerde zorg na een knieprothese verder te verbeteren en te personaliseren?

BAAS is niet uit het niets ontstaan. Over een periode van elf jaar implementeerde ziekenhuis Nij Smellinghe vier opeenvolgende zorgmodellen op de orthopedische afdeling: Joint Care, Function-tailored care, Fast-track care en Prehabilitation. Elk model hing samen met sneller herstel van activiteiten tijdens opname, kortere opnameduur en vaker ontslag naar de eigen woonsituatie — met telkens kleinere stappen naarmate de lat hoger lag. Dit laat zien dat gestructureerde, datagedreven zorgtransities het herstel tijdens opname kunnen verbeteren, maar ook dat er een grens zit aan wat je met klinisch gerichte zorg kunt winnen. BAAS was de logische volgende stap: niet meer focussen op wat er tijdens de opname gebeurt, maar op wat er daarna telt.

De haalbaarheidsstudie liet zien dat BAAS uitvoerbaar is in de dagelijkse praktijk. De meeste onderdelen van het zorgpad werden geleverd zoals bedoeld, patiënten ontvingen de geplande componenten, en zowel patiënten als professionals vonden het zorgpad zinvol en werkbaar. Het bereik was echter beperkt: 38% van de in aanmerking komende patiënten deed mee. De voornaamste drempel was de eis om fysiotherapie in het ziekenhuis te ontvangen, wat met name belastend was voor patiënten die verder weg woonden. Ook informeerde slechts 18% van

de orthopedisch chirurgen patiënten proactief over terugkeer naar werk — een punt dat in de verdere ontwikkeling van het zorgpad nadrukkelijk is opgepakt. BAAS was daarmee acceptabel en uitvoerbaar, maar aanpassing was nodig om de toegankelijkheid en schaalbaarheid te vergroten.

De multicenter effectiviteitsstudie liet zien dat patiënten in het BAAS-cohort eerder en vaker terugkeerden naar werk dan patiënten die gebruikelijke zorg ontvingen. De mediane tijd tot de eerste werkdag was 27 dagen in BAAS, tegenover 52 en 43 dagen in de twee gebruikelijke zorgcohorten. Ook volledige terugkeer naar de contractuele arbeidsuren werd eerder bereikt: een mediaan van 183 dagen in BAAS tegenover 210 dagen in de gebruikelijke zorg. Na twaalf maanden was 2% van de BAAS-deelnemers nog niet volledig teruggekeerd naar werk, tegenover 16% en 13% in de controlegroepen. Opvallend was dat sommige klinische uitkomsten — zoals kniefunctie in dagelijkse activiteiten — zelfs beter waren in de gebruikelijke zorggroep, terwijl participatie-uitkomsten juist in het voordeel van BAAS uitvielen. Dit laat zien dat klinisch herstel en participatieherstel niet hetzelfde zijn — en dat je het een niet vanzelf krijgt door het ander te optimaliseren.

De economische evaluatie liet zien dat BAAS positieve waarde genereerde. De interventiekosten bedroegen €845 per patiënt — bestaande uit de arbeidsdeskundige beoordeling, de accelerometer, de coördinatie door de medisch casemanager en een bijdrage aan fysiotherapie. Over twaalf maanden ging BAAS gepaard met €7.263 lagere verzuimkosten en €489 lagere kosten in de eerstelijnszorg, vergeleken met gebruikelijke zorg. Tweedelijnszorgkosten en presentisme lieten geen betekenisvolle verschillen zien. De gemiddelde netto baten bedroegen €4.493 vanuit werkgeversperspectief en €4.982 vanuit maatschappelijk perspectief, wat neerkomt op een rendement op investering van respectievelijk 532% en 590%. De implementatiekosten van BAAS werden daarmee ruimschoots terugverdiend, vooral doordat minder verzuim leidde tot minder productiviteitsverlies.

Tot slot onderzocht dit proefschrift hoe werkgeïntegreerde zorg na een knieprothese verder verbeterd kan worden. Een Cochrane prognostische review van 22 studies met in totaal 6.798 deelnemers liet zien dat terugkeer naar werk wordt beïnvloed door een samenspel van klinische, arbeidsgerichte en persoonlijke factoren: de fysieke werkbelasting, het type prothese, preoperatief ziekteverzuim en de verwachtingen van patiënten over hun herstel. Preoperatief ziekteverzuim en patiëntverwachtingen lieten de meest consistente verbanden zien met de tijd tot terugkeer naar werk, maar de zekerheid van het bewijs

was vaak laag of zeer laag — door risico op vertekening, heterogeniteit en inconsistente uitkomstdefinities. Aanvullend lieten de accelerometergegevens uit het BAAS-cohort zien dat meer matig intensieve activiteit vóór de operatie samenhang met eerdere volledige terugkeer naar werk, terwijl intensieve activiteit vóór de operatie en meer sedentaire episodes na de operatie juist samenhangen met vertraagde terugkeer. Herstelbegeleiding moet zich dus niet simpelweg richten op 'meer bewegen', maar ook aandacht besteden aan langdurig stilzitten na de operatie en aan individuele gedragspatronen rondom herstel.

BAAS biedt een concreet voorbeeld van participatiegeïntegreerde zorg: een model waarin het ziekenhuis terugkeer naar werk niet als een extern vraagstuk beschouwt, maar als een betekenisvolle gezondheidsuitkomst die besproken, gemeten, gecoördineerd en verbeterd kan worden. Tegelijkertijd blijft implementatie complex. Het bereik moet omhoog, bedrijfsartsen en werkgevers moeten eerder worden betrokken, en het zorgpad moet worden aangepast voor bredere toepassing in andere ziekenhuizen, regio's en patiëntgroepen.

Perioperatieve ziekenhuiszorg kan verder reiken dan pijnvermindering, betere mobiliteit en implantaatoverleving — naar uitkomsten die er in het echte leven van patiënten toe doen. De resultaten laten zien dat participatiegeïntegreerde zorg niet iets is voor de verre toekomst — het werkt nu al, in een gewoon regionaal ziekenhuis. De volgende stap is om dergelijke modellen te verfijnen, op te schalen en te evalueren bij andere chirurgische patiëntgroepen en in andere zorgsystemen — zodat herstel na een ziekenhuisopname niet alleen wordt beoordeeld op wat er binnen de ziekenhuismuren gebeurt, maar ook op de vraag of mensen de rollen en activiteiten kunnen hervatten die hun leven vormgeven.

A P P E N D I X

2

About the author

About the author

Daniël Otto Strijbos was born on the 19th of December 1991 in Groningen, the Netherlands. After completing secondary education at CSG Liudger (HAVO) and Drachtster Lyceum (VWO), he enrolled in medical school — a logical choice on paper, but one that did not work out. Failing his first-year exams was a hard blow, though in hindsight, it set him on a better path. He enrolled in Physiotherapy at the Hanze University of Applied Sciences in Groningen, initially as a plan B. It turned out to be the right fit. The combination of hands-on patient care and the possibility to think beyond the individual patient suited him far better than he had anticipated.

During his undergraduate research project under supervision of Dr. G. van der Sluis, he focused on prehabilitation among orthopedic patients. The project was nominated for the Crux Prize, awarded to one of the best practice-oriented research projects of the year at Hanze University of Applied Sciences. More importantly, it was during this period that Daniël began to notice something that would shape the rest of his career: what mattered most to patients was rarely a pain score or a range-of-motion measurement. It was whether they could go back to work, care for their grandchildren, or simply get on with their lives. That gap — between what healthcare measures and what patients actually care about — became the central question he kept returning to.

Driven by that question, Daniël combined clinical work with further education and completed the Master's program in Clinical Health Sciences while working as a physiotherapist, first in an outpatient rehabilitation setting, then at the University Medical Center Groningen, and later at Nij Smellinghe Hospital. At Nij Smellinghe, he progressed from junior project leader to senior project leader and eventually to Program Manager Research & Innovation.

Throughout these years, he kept working one day per week as a physiotherapist. Research gains from staying connected to practice: knowing how care actually works in a regional hospital makes for better questions, sharper implementation, and findings that are harder to ignore. It also made patient contact more enjoyable — understanding the broader system made the individual encounters richer.

This combination of clinical work and research led to the development of the Back At work After Surgery (BAAS) pathway. It started with a question from insurance company a.s.r. Nederland: could patients be better prepared before surgery to improve return to work? That question, asked to a regional hospital in Drachten,

grew into a research program funded by ZonMw, a Cochrane systematic review, and eventually a care pathway that is now implemented as routine care at Nij Smellinghe. During his PhD trajectory, Daniël and his colleagues received five awards recognizing the scientific quality and societal impact of their work — including the first and second prize of the Dr. Michael Feuerstein Best Paper Award of the Journal of Occupational Rehabilitation in 2026.

Currently, Daniël works as Program Manager Research & Innovation at Nij Smellinghe, where he leads the IMPACT! program: a strategic initiative aimed at reducing the impact of a hospital admission on patients' lives — before, during, and after hospitalization. His work continues to sit at the intersection of clinical practice, science, and implementation. The goal has not changed since his undergraduate days: to make sure that what happens in healthcare actually reflects what matters to the people it is meant to serve.

Portfolio Daniël Otto Strijbos

PhD period: 2022-2026

PhD supervisors: dr. P.P.F.M. Kuijer, prof. dr. M.F. Reneman

PhD co-supervisors: dr. G van der Sluis, dr. T E. A. J. Boymans

1. PhD training		
	Year	ECTS
General courses		
- Evidence Based Functional Capacity Evaluation	2022	1.5
- ISBNPA Implementation Science	2023	1.5
Presentations		
- Back At work After Surgery NVBF & NVRF, May 2022, Oral presentation	2022	0.5
- Samen werken aan duurzame zorg Ministry of VWS (min. Kuipers), Feb 2022, Oral presentation	2022	0.8
- Perioperatieve gezondheid en zorg Lector disertation G. Sluis, March 2023, Oral presentation	2023	0.4
- Perioperatieve gezondheid en zorg Heelkunde Friesland, May 2023, Oral presentation	2023	0.5
- Perioperatieve gezondheid en zorg, Fysio Game, June 2023, Workshop	2023	0.5
- Effectiveness of BAAS AMC Short Presentation, Feb 2024	2024	0.3
- Veerkracht rondom een grote operatie ROS Zorgadvies Groningen, March 2024, oral presentation	2024	0.5
- Expand Research Afternoon AMC, April 2024, poster and oral presentation	2024	0.5
- Waarom doen bedrijfsartsen niet mee met BAAS? BG dagen, May 2024, poster and oral presentation	2024	0.8
- Optimale terugkeer naar werk na een operatie COP peri-operative zorg, Sept 2024, oral presentation	2024	0.5
- Bewegen rondom een knieprothese operatie Expertgroep beweegmonitoring, Sept 2024, oral presentation	2024	0.5
- Hoe stimuleer je een actieve bijdrage van patiënten? NVZF, March 2025, oral presentation	2025	0.5
- More patients return to work after knee arthroplasty with BAAS BG dagen, May 2025, poster presentation	2025	0.3
- BAAS: snellere terugkeer naar werk na een knieprothese NOV Jaarcongress, May 2025, oral presentation	2025	0.5
- BAAS: snellere terugkeer naar werk na een knieprothese AMC, June 2025, oral presentation	2025	0.5
- BAAS: earlier return to work after knee arthroplasty Early morning meeting AMC, June 2025, oral presentation	2025	0.5
- Symposium BAAS Nij Smellinghe, June 2025, oral presentation	2025	0.8
- Symposium BAAS Nij Smellinghe, May 2026, oral presentation	2026	0.4
- What could BAAS achieve for the Netherlands every year? AMS annual research meeting, poster and oral presentation	2026	0.5
- BAAS zorgpad Heel Holland Werkt, April 2026, oral presentation	2026	0.5
- Platformbijeenkomt Arbeidsgerelateerde Zorg BAAS zorgpad, April 2026, oral presentation	2026	0.5

1. PhD training continued		
	Year	ECTS
(Inter)national conferences		
- International Forum on Quality & Safety in Healthcare June 2022, Gothenburg Sweden, participant	2022	2.1
- International Forum on Quality & Safety in Healthcare May 2023, Copenhagen, Denmark, poster presentation	2023	2.3
- PREMUS, WDPI & Myopain November 2023, Bangalore, India, workshop presentation	2023	3.1
- World Congress of Physiotherapy May 2025, Tokyo, Japan, oral and poster presentation	2025	3.3
- PREMUS September 2025, Tübingen, Germany, oral presentation	2025	2.5
2. Teaching		
	Year	ECTS
- Guest lecture at Saxion University of Applied Sciences November 2023, Deventer, the Netherlands	2023	1.0
- Guest lecture at Hanzehogeschool December 2024, Groningen, the Netherlands	2024	1.0
- Guest lecture at Saxion University of Applied Sciences Jun 2026, Deventer, the Netherlands	2026	1.0
3. Parameters of Esteem		
	Year	
Grants		
- ZonMw: Perioperatief multidisciplinair zorgpad voor snellere re-integratie bij werkenden die een knieprothese krijgen Projectnummer: 10320052010006. Amount: €400.000	2021	
- APH-SP&H Societal Participation & Health 2021 Amount: €9.000	2021	
- AKC: Pre-WERK Amount: €75.000	2025	
Awards and Prizes		
- Top Cited Article 2022-2023 in Musculoskeletal Care: <i>"Implementation of back at work after surgery (BAAS): A feasibility study of an integrated pathway for improved return to work after knee arthroplasty"</i>	2022	
- 1 st prize: Dr. Michael Feuerstein Best Paper Award Journal of Occupational Rehabilitation 2026: <i>"The Effectiveness of the Back At work After Surgery (BAAS) Work-Integrated Care Pathway on Return to Work for Patients Receiving Knee Arthroplasty: A Study of Three Comparative Cohorts in the Netherlands"</i>	2026	
- 2 nd prize: Dr. Michael Feuerstein Best Paper Award Journal of Occupational Rehabilitation 2026: <i>"Return on Investment of the Back At Work After Surgery (BAAS) Care Pathway Compared to Care-as-Usual in Knee Arthroplasty"</i>	2026	
- Outstanding Paper Award Amsterdam Movement Science 2026: <i>"The Effectiveness of the Back At work After Surgery (BAAS) Work-Integrated Care Pathway on Return to Work for Patients Receiving Knee Arthroplasty: A Study of Three Comparative Cohorts in the Netherlands"</i>	2026	
- Societal Impact Award Amsterdam Movement Science 2026: <i>"Back At work After Surgery (BAAS): From Research to Care-as-Usual in Work Integrated Orthopedic Care"</i>	2026	

4. Publications	
	Year
Peer reviewed	
- Srijbos DO, van der Sluis G, Boymans TAEJ, et al. Implementation of Back At work After Surgery (BAAS): a feasibility study of an integrated pathway for improved return to work after knee arthroplasty. <i>Musculoskelet Care</i> . 2022;20(4):950–959. doi:10.1002/msc.1633.	2022
- Srijbos DO, van der Sluis G, van Houtert WFC, et al. Protocol for a multicenter study on effectiveness and economics of the Back At work After Surgery (BAAS): a clinical pathway for knee arthroplasty. <i>BMC Musculoskelet Disord</i> . 2023;24:199. doi:10.1186/s12891-023-06203-5.	2023
- Srijbos DO, Boymans TAEJ, Bimmel R. Near-optimal recovery within 3 months: investigating health-related quality of life and functional outcomes after single-stage bilateral hip replacement for osteoarthritis. <i>Orthop Nurs</i> . 2023;42(6):376–382. doi:10.1097/NOR.0000000000000987.	2023
- Srijbos DO, Straat AC, van der Sluis G, et al. Prognostic factors for return to work following knee arthroplasty. <i>Cochrane Database Syst Rev</i> . 2024;(4):CD015272. doi:10.1002/14651858.CD015272.	2023
- van Houtert WFC, Srijbos DO, Bimmel R, et al. A stepwise transformation: description and outcome of perioperative procedures in patients receiving a total knee arthroplasty. <i>Bone Joint J</i> . 2024;106-B(6):573–581. doi:10.1302/0301-620X.106B6.BJJ-2023-0819.R2.	2024
- Rietdijk HH, Srijbos DO, Conde-Cespedes P, et al. Feature selection with small data sets: identifying feature importance for predictive classification of return-to-work date after knee arthroplasty. <i>Appl Sci</i> . 2024;14:9389. doi:10.3390/app14209389.	2024
- Srijbos DO, van der Sluis G, van Houtert WFC, et al. The effectiveness of the Back At work After Surgery (BAAS) work-integrated care pathway on return to work for patients receiving knee arthroplasty. <i>J Occup Rehabil</i> . 2025;35:967–977. doi:10.1007/s10926-025-10331-1.	2025
- Srijbos DO, Straat AC, van der Sluis G, et al. Return on investment of the Back At Work After Surgery (BAAS) care pathway compared to care-as-usual in knee arthroplasty. <i>J Occup Rehabil</i> . 2025;35:958–966. doi:10.1007/s10926-025-10328-w.	2025
- Kuijer PPFM, van der Sluis G, Boymans T, Reneman MF, Srijbos DO. Three game-changing actions that show how physical therapists pave the path back to work for patients receiving knee arthroplasty. <i>Phys Ther Korea</i> . 2025;32(3):193–198. doi:10.12674/ptk.2025.32.3.193.	2025
- Srijbos DO, van Houtert WFC, Arends JJ, et al. Sedentary behaviour after surgery is associated with delayed full return to work among patients receiving knee arthroplasty within the Back At work After Surgery (BAAS) work-integrated care cohort. <i>Eur J Physiother</i> . 2026. doi:10.1080/21679169.2026.2663833.	2026
- Straat AC, Kuijer PPFM, Srijbos DO, et al. Economic evaluation alongside the multicenter randomized controlled ACTIVE trial: cost-effectiveness of an integrated personalized eHealth program for working-age knee arthroplasty patients. <i>Musculoskelet Sci Pract</i> . 2026;84:103573. doi:10.1016/j.msksp.2026.103573.	2026
- Srijbos DO, van der Sluis G, Boymans T, et al. Geïntegreerde medische en bedrijfsgeneeskundige zorg gecoördineerd door het ziekenhuis loont voor werkenden en werkgevers bij een knieprotheseoperatie [Integrated medical and occupational healthcare coordinated by the hospital pays off for workers and employers after knee arthroplasty]. <i>Ned Tijdschr Geneesk</i> . Accepted, awaiting publication.	2026
- Srijbos DO, Straat AC, van der Sluis G, et al. Prognostic factors for return to work following knee arthroplasty. <i>Cochrane Database Syst Rev</i> . Submitted, awaiting peer review.	2026

Other

- Strijbos D, van der Sluis G, Boymans T, et al. Nieuw zorgpad naar werk: werkgerichte begeleiding na knieprotheseoperatie. *TBV – Tijdschrift voor Bedrijfs- en Verzekeringsgeneeskunde*. 2022;30(4):31–35. doi:10.1007/s12498-022-1488-5. 2022
 - Kuijer P, Strijbos D, Reneman M. FCE: maak je werk leuker en doelmatiger. *TBV – Tijdschrift voor Bedrijfs- en Verzekeringsgeneeskunde*. 2024;32(4):8–11. doi:10.1007/s12498-024-2491-9. 2024
 - Strijbos DO, van der Sluis G, Boymans TAEJ, Reneman MF, Kuijer PPFM. Eerder terug naar werk met een knieprothese. *FysioPraxis*. 2025;(8):40–41. 2025
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A P P E N D I X

3

Dankwoord

Lieve Sanne en Thijn,

Papa is de afgelopen jaren soms erg druk geweest met zijn werk en met het onderzoek in dit boekje. Gelukkig hebben we tijdens onze drie maanden in Nieuw-Zeeland volop tijd met elkaar gehad. Dat was een prachtige periode, waarin we samen zoveel hebben gezien en beleefd dat het bijna verslavend werd.

Ik hoop dat jullie later zullen begrijpen waarom dit onderzoek zoveel tijd en aandacht vroeg. Papa heeft hiermee geprobeerd de zorg voor mensen een beetje beter te maken en hen te helpen om na een operatie hun gewone leven weer zo goed mogelijk op te pakken. Maar hoe belangrijk mijn werk ook is, jullie zijn en blijven voor mij het allerbelangrijkst.

Lieve Joyce, lieve schat, lieve paranimf,

Dat ik zoveel plezier uit mijn werk haal en er soms volledig in kan opgaan, is voor jou niet altijd even gemakkelijk te begrijpen. Juist daarom betekent het veel voor mij dat je mij steeds de tijd en vrijheid hebt gegeven om aan dit onderzoek en proefschrift te werken. Je hebt mij gesteund, ook op de momenten waarop mijn aandacht misschien iets te vaak bij mijn werk lag.

De mooie gesprekken die we samen over mijn werk, mijn keuzes en alles daaromheen hebben, betekenen veel voor mij. Dat jij op deze belangrijke dag, samen met mijn vader, als paranimf naast mij staat, maakt het voor mij extra mooi. Dank je wel voor je vertrouwen, je geduld en vooral voor alles wat we samen hebben.

Lieve pap en mam,

Van jullie heb ik geleerd om nieuwsgierig te blijven, hard te werken en verantwoordelijkheid te nemen voor de mensen om je heen. Jullie hebben mij altijd gestimuleerd om mijn eigen weg te kiezen, ook wanneer die weg niet helemaal recht liep.

Pap, jij werkte jarenlang als longarts in hetzelfde ziekenhuis waar ik later zelf terechtkwam. Dat we elkaar daar zo vaak tegenkwamen, gaf mijn werkende leven iets extra's. Ook jouw eigen ervaring met onderzoek heeft hierin altijd meegespeeld. Het boekje kwam er destijds bij jou niet, maar je hebt nooit onder stoelen of banken gestoken hoe trots je bent dat ik het nu heb afgemaakt. Dat betekent veel voor mij. Dat jij vandaag bovendien als paranimf naast mij staat, maakt de cirkel helemaal rond.

Mam, jij werkte als docent op dezelfde school waar ik leerling was. Ook daardoor was er tijdens een groot deel van mijn opleiding en loopbaan altijd een ouder dichtbij. Dat voelde destijds misschien heel gewoon, maar achteraf besef ik hoe speciaal dat was. Jouw nuchterheid, steun en oprechte interesse hebben mij altijd geholpen om door te gaan.

Mijn eerste poging om arts te worden strandde vroegtijdig. Misschien is dit proefschrift daarom toch een kleine vorm van compensatie. Via een andere route ben ik uiteindelijk precies terechtgekomen op de plek die bij mij past. Dank jullie wel voor het vertrouwen en voor de basis die jullie mij hebben meegegeven.

Lieve Hilco en Charlotte,

Hilco, vroeger konden we het elkaar soms behoorlijk lastig maken, maar ik ben dankbaar voor de goede band die we nu hebben. Ik bewonder hoe jij uiteindelijk een plek hebt gevonden waar je jouw kwaliteiten en zorgzaamheid volledig kwijt kunt. Je zet je in voor kinderen die wat extra aandacht nodig hebben. Die aandacht voor anderen is iets wat we met elkaar delen. Samen met Arlette, Isabel en Julian heb je een prachtig gezin opgebouwd. Hoewel jullie wat verder weg wonen, is het fijn dat we elkaar regelmatig blijven zien en dat onze kinderen samen kunnen opgroeien.

Lieve Charlotte, dat je schuin achter ons woont, maakt dat we gemakkelijk bij elkaar binnenlopen en veel van elkaars leven meekrijgen. Samen afzien op de spinningfiets, op een zomerse avond de barbecue aansteken met een glas witte wijn erbij, of lp's uitwisselen omdat onze muzieksmaak vrijwel hetzelfde is: het zijn juist die gewone momenten die voor mij veel betekenen. Samen met Arjen heb ook jij een warm en mooi thuis gecreëerd.

Ik vind het mooi om te zien hoe jullie allebei, ieder op jullie eigen manier, jullie leven vormgeven. Ik ben blij met hoe onze band zich heeft ontwikkeld en dankbaar dat jullie zo'n belangrijk onderdeel van mijn leven zijn.

Beste Paul,

Ik herinner me onze eerste kennismaking nog goed: online, op 12 augustus 2020, gevolgd door een afspraak in Grand Café ZO in Amsterdam op 8 oktober. Daarna schreven we in hoog tempo aan een subsidieaanvraag. Een jaar later hadden we samen 400.000 euro van ZonMw binnengehaald. Uniek, als je het mij vraagt.

Dankzij jou kreeg ik de kans om promotieonderzoek te doen zoals ik het voor me had gezien: met een eigen onderwerp en met de mogelijkheid om het onderzoek

binnen werktijd uit te voeren. Minstens zo kenmerkend was jouw manier van begeleiden. Je was voor mij vrijwel dagelijks bereikbaar. Vakantie of niet, ochtend of avond, als ik een vraag had, stond je klaar. Die enorme inzet is allesbehalve vanzelfsprekend.

Samen reisden we naar India, Tokio en Tübingen. Wanneer ik een scholing in Amsterdam volgde, kon ik zelfs bij jullie thuis blijven slapen, waarna we 's avonds met Astrid erbij nog een glas wijn dronken. In de jaren van begeleiding ben je voor mij dan ook veel meer geworden dan alleen een promotor of collega.

Dank je wel voor je vertrouwen, je tomeloze inzet en voor alles wat je mogelijk hebt gemaakt.

Beste Michiel,

Toen ik je vroeg of je naast Paul mijn promotor wilde worden, mocht ik eerst bij je thuis langskomen. Gelukkig was de fietstocht goed te overzien: je woonde op slechts een paar honderd meter van mijn toenmalige huis. Dat ik als Groninger inmiddels naar Friesland was verhuisd, viel bij jou iets minder goed dan het glas wijn dat we die avond buiten dronken. Terwijl de zon boven de weilanden onderging, leerden we elkaar op een ontspannen en prettige manier kennen.

Tijdens mijn promotietraject was jij degene die scherp bleef op precisie én steeds het perspectief van de patiënt bewaakte. De termen *artrosepatiënten* — “een patiënt wordt niet door zijn aandoening gedefinieerd, Daniël” — en *undergoing surgery* — “je ondergaat geen operatie, maar kiest ervoor” — bleken bij mij hardnekkig. Toch heb ik jouw kritische feedback altijd zeer gewaardeerd. Ook wanneer we het niet met elkaar eens waren, konden we daar open en inhoudelijk over spreken. Dat heb ik als zeer prettig ervaren en het heeft mijn werk beter gemaakt.

We delen de passie om de fysiotherapeutische zorgpraktijk met wetenschap te verbinden. Dat jij naast je wetenschappelijke werk nog altijd een dag per week aan het bed staat, vind ik inspirerend. Dat voorbeeld volg ik de komende jaren graag.

Dank je wel voor je scherpe blik, je inzet en de prettige manier waarop je mij hebt begeleid.

Beste Geert,

Tijdens mijn afstudeeronderzoek voor de opleiding Fysiotherapie liet jij mij al zien hoe relevant en leuk het is om vanuit de dagelijkse zorgpraktijk onderzoek te doen. Ik mocht destijds meewerken aan jouw onderzoek naar prehabilitatie bij patiënten

met orthopedische klachten. Mijn afstudeeronderzoek werd uiteindelijk tot de drie beste van dat jaar gerekend, wat ook iets zegt over hoe vernieuwend het onderzoek was waarmee jij toen al bezig was.

Uit die eerste samenwerking ontstond niet alleen een langdurige professionele samenwerking, maar ook een hechte vriendschap. Dat jij later als copromotor bij mijn promotietraject betrokken raakte, voelde dan ook heel vanzelfsprekend. Je kent mijn manier van werken, weet waar mijn kracht ligt en bent altijd in staat geweest om wetenschap en praktijk met elkaar te verbinden.

We hebben inmiddels talloze avonden mooie gesprekken gevoerd over muziek, werk en het leven. Ons wandeloverleg op maandagochtend is nog altijd een van de beste momenten van mijn week. We vullen elkaar goed aan, kunnen eerlijk tegen elkaar zijn en werken daardoor ontzettend prettig samen.

Ook de reizen die we samen voor congressen hebben gemaakt, waren altijd memorabel. De inhoud was belangrijk, maar minstens zo fijn waren de gesprekken en de gezelligheid daaromheen.

Dank je wel voor alles wat je mij als copromotor, onderzoeker, collega en vriend hebt meegegeven. Die samenwerking, de wandelingen en de congresreizen houden we erin, vriend.

Beste Tim,

Als mijn copromotor bracht jij niet alleen je wetenschappelijke en klinische expertise in, maar vooral ook je brede blik op de patiënt. Als orthopedisch chirurg kijk jij verder dan het gewricht alleen. Je hebt oog voor de persoon achter de aandoening en voor alles wat iemand nodig heeft om goed te kunnen functioneren. Die benadering sloot naadloos aan bij de kern van dit promotieonderzoek.

Het was niet de eerste keer dat je met ons ziekenhuis in aanraking kwam. Je was eerder al eens langs geweest en herinnerde je zelfs nog de auto waarmee we patiënten laten oefenen met het in- en uitstappen. Met het Beweeghuis laat je zien dat een operatie niet het beginpunt van het gesprek hoeft te zijn, maar juist een van de laatste behandelopties kan zijn. Die visie op bewegen, gezondheid en passende zorg sluit sterk aan bij waar wij met BAAS voor staan. In de toekomst moeten we deze concepten dan ook zeker nog eens met elkaar verbinden.

Voor ons jaarlijkse onderzoeksdiner moest jij vaak de grootste afstand afleggen: vanuit Maastricht naar Utrecht of zelfs naar Beetsterzwaag. Daarom was het extra

leuk dat wij in 2023 jouw stad mochten bezoeken en daar samen heerlijk hebben gegeten.

Dank je wel voor je inzet als copromotor, je brede blik en je betekenisvolle bijdrage aan dit onderzoek.

Geachte professor **Margot Joosen**, professor **Frederieke Schaafsma**, professor **Wendy Scholten-Peeters**, doctor **Rutger van Geenen**, professor **Gino Kerkhoffs** en professor **Sjoerd Repping**, hartelijk dank voor de tijd en moeite die u erin heeft gestoken voor het beoordelen van mijn proefschrift, en alvast bedankt voor uw aanwezigheid en de vragen tijdens de verdediging van dit proefschrift.

Beste Carlien en Yvonne,

Met jullie heb ik tijdens dit promotietraject intensief samengewerkt. De gegevens uit jullie onderzoeken vormden een onmisbare basis om de effectiviteit en economische waarde van BAAS te kunnen aantonen. Maar onze samenwerking ging veel verder dan alleen het delen van data en het schrijven van artikelen.

Carlien, vooral tijdens de Cochrane-review hebben we ontelbaar veel uren samen doorgebracht. Op een gegeven moment waren we er allebei helemaal klaar mee. Toch waren de lange werkdagen aan de tafel in jouw huiskamer in Zwolle, met een 'gebakje zonder naam' van de bakker, altijd erg gezellig. Gelukkig wist Paul ons telkens opnieuw te motiveren met de boodschap dat een Cochrane-review Champions League is en geen kelderklassevoetbal. Uiteindelijk hebben we samen doorgezet en mogen we trots zijn op het resultaat.

Yvonne, ook met jou heb ik aan meerdere studies en publicaties mogen werken. Je stelde niet alleen de gegevens uit jouw onderzoek beschikbaar, maar dacht steeds inhoudelijk en constructief mee. Jouw kennis, inzet en ontspannen manier van samenwerken heb ik enorm gewaardeerd.

Een hoogtepunt was onze schrijfweek met Paul in Thumersbach. In het huisje in Oostenrijk zouden we grote stappen zetten met onze artikelen. Van het schrijven kwam misschien iets minder terecht dan gepland, maar gezellig was het des te meer.

Onze band is inmiddels veel meer dan alleen professioneel. Dat ik samen met Yvonne paranimf mag zijn bij jouw promotie, Carlien, zegt veel over de hechte band die uit onze samenwerking is ontstaan. Dank jullie wel voor het vertrouwen,

de vele uren samen, het doorzettingsvermogen en vooral voor alle gezelligheid daaromheen.

Beste Rutger, Kyle, David, Dabian, Mark, Job, Marten en Rick,

Al sinds de middelbare school vormen we een hechte vriendengroep. Inmiddels wonen we verspreid over Delft, Amsterdam, Groningen, Amersfoort, Drachten en Beetsterzwaag, maar ons gezamenlijke fundament is sterk genoeg om de afstand moeiteloos te overbruggen. Zodra we bij elkaar zijn, voelt het altijd weer vertrouwd.

Dat kan in kleinere groepjes zijn, tijdens een rondje golf of met een biertje, maar ook tijdens ons jaarlijkse weekend in een huisje op de hei. De avonturen die we samen hebben beleefd, bieden waarschijnlijk voldoende stof voor een heel ander boek — en vele daarvan zijn wellicht minder geschikt voor dit proefschrift.

Dank jullie wel voor alle jaren vriendschap, de humor, de gezelligheid en de vele mooie herinneringen. Het betekent enorm veel om vrienden te hebben bij wie je, ongeacht tijd of afstand, altijd weer kunt aansluiten.

Beste collega's,

Ik vind het prachtig dat we binnen ons ziekenhuis de mogelijkheid krijgen om verder te denken dan de standaardzorg. Dat doe je niet als individu, maar als team en als organisatie. Met velen van jullie heb ik de afgelopen jaren gesproken over de vraag hoe we de zorg kunnen verbeteren. Samen hebben we daarin ieder jaar opnieuw mooie stappen gezet.

Nij Smellinghe biedt veel ruimte aan vernieuwing en verbetering. Ik ben er trots op dat ik daar samen met jullie aan mag bijdragen. Hopelijk liggen er nog vele jaren voor ons waarin we de zorg steeds een beetje beter blijven maken.

Hoewel iedereen binnen het ziekenhuis daaraan bijdraagt, wil ik een aantal mensen in het bijzonder bedanken.

Bert Kleinlugtenbeld, we zijn ongeveer tegelijkertijd bij Nij Smellinghe begonnen. Vanaf het begin heb jij mij de vrijheid gegeven om nieuwe ideeën uit te proberen. Inmiddels ben je ook al enkele jaren mijn direct leidinggevende. Je denkt niet alleen mee over hoe we zaken het beste kunnen aanpakken, maar vervult ook een belangrijke coachende rol in mijn verdere ontwikkeling. Je voert kritische gesprekken met mij, houdt mij een spiegel voor en geeft mij een inkijkje in het werk en de afwegingen van een bestuurder. Dat ik op deze manier met

de Raad van Bestuur van ons ziekenhuis mag samenwerken, is allesbehalve vanzelfsprekend. Dank je wel voor het vertrouwen en de kansen die je mij geeft.

Jasmijn Wieringa, jouw prettige manier van samenwerken viel mij al op toen je mijn leidinggevende in het UMCG was. Sinds jij binnen Nij Smellinghe verantwoordelijk bent voor de Medisch Ondersteunende Diensten en wij samenwerken binnen 'ons' IMPACT!-programma, is die samenwerking alleen maar verder versterkt. We spreken vaak dezelfde taal, begrijpen snel wat de ander bedoelt en delen dezelfde ambitie. Daardoor kunnen we ideeën snel omzetten in concrete stappen. Ik kijk ernaar uit om samen nog veel mooie ontwikkelingen in gang te zetten.

Gerda Woudstra, ook al ben je officieel geen collega meer, zo voelt dat voor mij nog steeds. Weet je nog dat we samen in het Van der Valk Hotel in Hoogkerk de eerste versie van BAAS uittekenden? Daar werd een belangrijke basis gelegd voor het zorgpad, maar ook voor de vele goede gesprekken die we sindsdien hebben gevoerd. Gelukkig zetten we die gesprekken, ook na je vertrek uit Nij Smellinghe, nog regelmatig voort. Dank je wel voor je bijdrage aan het ontstaan van BAAS en voor het contact dat is gebleven.

Helma de Jong, Mirthe Spoelstra en Linda Kleefstra, samen met Geert hebben we toch maar een ontzettend gezellig kantoor gecreëerd. Het is altijd fijn om bij jullie op de kamer te mogen werken, bij te praten en tussendoor ook nog iets gedaan te krijgen.

Collega's van de afdeling Orthopedie, dank voor het vertrouwen dat jullie vanaf het begin in BAAS hebben gesteld. Jullie gaven ons de mogelijkheid om een nieuw idee uit te proberen binnen de zorg voor jullie patiënten en bleven bereid om mee te denken over de verdere ontwikkeling ervan. Zonder die open houding had BAAS nooit in de dagelijkse praktijk kunnen ontstaan en groeien.

In het bijzonder wil ik **Carolien Kooijman** bedanken. Jij bent vanaf het begin intensief betrokken en hebt aan alle onderzoeken en publicaties meegewerkt. Je inhoudelijke bijdrage, klinische blik en niet-aflatende inzet zijn van grote betekenis voor BAAS en dit onderzoek.

Gijs van Stralen en Richard Bimmel, bij jullie kan ik altijd binnenstappen om een nieuwe gedachte, vraag of ontwikkeling rondom BAAS te bespreken. Jullie geven mij de vrijheid om ideeën hardop te verkennen, denken kritisch en constructief mee en hebben ons de mogelijkheid geboden om het zorgpad bij 'jullie' patiënten

uit te proberen. Die toegankelijkheid en het vertrouwen dat jullie ons geven, waardeer ik enorm.

Collega's van team Fysiotherapie, dankzij jullie heb ik de mogelijkheid gekregen om naast de directe patiëntenzorg ook onderzoek en andere projecten uit te voeren. Dat betekende soms dat anderen in de zorg een stap extra moesten zetten, zodat ik tijd kreeg om aan dit promotietraject te werken. Ik realiseer me heel goed hoe waardevol dat is. Jullie flexibiliteit, collegialiteit en bereidheid om elkaar iets te gunnen, kenmerken voor mij ons team.

En dan nog in het bijzonder **Audrey Veenema**. Ik weet nog goed dat ik de eerste stagiair was die jij begeleidde. Op de afdeling Orthopedie hebben we toen al ontzettend veel plezier gehad. Inmiddels zijn we vele jaren verder, maar het is nog altijd iedere keer een feest om met je samen te werken. Dank je wel voor je enthousiasme, humor en collegialiteit.

Beroepsverenigingen en samenwerkingspartners

BAAS kon alleen ontstaan door samenwerking tussen partijen uit de ziekenhuiszorg, fysiotherapie, orthopedie, arbeid, werkgevers en sociale zekerheid. Dit onderzoek had nooit door één persoon of één organisatie uitgevoerd kunnen worden.

Allereerst wil ik a.s.r. bedanken. In samenwerking met jullie is BAAS begonnen. **Simon Klomp** en **Bert Schmaal** behoorden, samen met ons, tot de pioniers die geloofden dat ziekenhuiszorg zich niet alleen moest richten op de operatie en het fysieke herstel, maar ook op een goede terugkeer naar werk. In een tijd waarin die verbinding nog allesbehalve vanzelfsprekend was, durfden jullie met ons nieuwe zorg te ontwikkelen en in de praktijk uit te proberen.

Bert is helaas enkele jaren geleden overleden en heeft de verdere ontwikkeling van BAAS niet meer kunnen meemaken. Zijn visie, vertrouwen en pioniersgeest zijn echter onlosmakelijk verbonden met het ontstaan van het zorgpad. Simon, jouw voortdurende inzet en bereidheid om samen te blijven zoeken naar manieren om BAAS verder te brengen, betekenen veel voor mij. Zonder jullie vertrouwen en de mogelijkheden die a.s.r. ons bood, was BAAS waarschijnlijk nooit geworden wat het vandaag is.

Daarnaast wil ik ZonMw bedanken. Dankzij de financiële ondersteuning kregen we de mogelijkheid om BAAS op grotere schaal te onderzoeken en de effectiviteit en economische waarde van het zorgpad zorgvuldig te evalueren.

Ook Amsterdam UMC, Maastricht UMC+, het Universitair Medisch Centrum Groningen, het Elisabeth-TweeSteden Ziekenhuis en de Hanzehogeschool Groningen wil ik bedanken voor hun bijdrage aan de ontwikkeling en uitvoering van het onderzoek.

Naast de mensen die ik hierboven al persoonlijk heb genoemd, wil ik ook alle coauteurs bedanken met wie ik aan de verschillende studies in dit proefschrift heb mogen werken. Ieder van jullie bracht vanuit een eigen vakgebied kennis, ervaring en een kritische blik mee. Jullie bijdragen aan de methodologie, statistiek, bewegingsmetingen, arbeidsgerichte begeleiding en gezondheidseconomische evaluatie hebben de afzonderlijke onderzoeken beter gemaakt. Dank voor jullie inzet en de prettige manier waarop we hebben samengewerkt.

Ook de ondersteuning van anderen was onmisbaar. Peercode, met name **Govert de Vries**, maakt het mogelijk om patiënten digitaal te volgen en de professionals rondom de patiënt met elkaar te verbinden. Elabo hielp met de arbeidsdeskundige ondersteuning en **Stephan de Groot** en **Baukje de Groot** heeft daar in het bijzonder altijd fijn over meegedacht! Indiveo hielp vervolgens om het BAAS-zorgpad op een begrijpelijke en visuele manier aan patiënten uit te leggen.

De steun van de betrokken patiënten en beroepsverenigingen heeft eveneens veel betekend. Ik wil het Koninklijk Nederlands Genootschap voor Fysiotherapie, de Nederlandse Vereniging voor Bedrijfs- en Arbeidsfysiotherapeuten, de Nederlandse Vereniging voor Arbeids- en Bedrijfsgeneeskunde, de Nederlandse Vereniging voor Verzekeringsgeneeskunde, de Nederlandse Vereniging van Arbeidsdeskundigen, de Nederlandse Orthopaedische Vereniging en ReumaNederland bedanken voor het onderschrijven van het belang van betere samenwerking tussen zorg en arbeid. Ik hoop dat we deze verbinding de komende jaren gezamenlijk verder kunnen versterken.

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Beste patiënten,

Tot slot wil ik alle patiënten bedanken die aan de onderzoeken in dit proefschrift hebben deelgenomen. Jullie vulden vragenlijsten in, droegen bewegingsmeters, lieten arbeidsdeskundigen meekijken op het werk en deelden ervaringen uit een periode waarin herstel, onzekerheid en de terugkeer naar het dagelijks leven veel van jullie vroegen. Dat jullie daarvoor tijd en vertrouwen aan ons hebben gegeven, is niet vanzelfsprekend.

Jullie hebben mij laten zien dat een geslaagde behandeling over veel meer gaat dan een goed uitgevoerde operatie of een hersteld gewricht. Het gaat erom dat iemand weer kan deelnemen aan het leven: thuis, in de samenleving en op het werk. Jullie verhalen en ervaringen vormden daarom niet alleen de gegevens voor dit onderzoek, maar ook steeds opnieuw de motivatie om ermee door te gaan.

Zonder jullie was dit proefschrift er niet geweest. Ik hoop dat jullie deelname eraan bijdraagt dat toekomstige patiënten na een operatie beter worden begeleid bij het hervatten van hun leven en werk. Daar is dit boek uiteindelijk voor geschreven.

