KAIPONAPONA AOTEAROA

A clear cut case

Evidence for non-surgical, non-pharmacologic models of care in hip and knee osteoarthritis

NZIER report to Arthritis New Zealand

15 August 2022

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Authorship

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The assistance of Sarah Spring is gratefully acknowledged.

Acknowledgements

Arthritis New Zealand would like to very warmly thank all those who were involved in the peer review process associated with the preparation of this report.

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Key points

Arthritis New Zealand commissioned NZIER to identify the most robust recent evidence to review the case for investment in non-surgical, guideline-informed models of care for osteoarthritis (OA) of the hip and/or knee.

A wide range of non-surgical interventions are described in the published literature. A two-stage search for evidence, expert advice and internationally published guidelines identified a range of interventions supported by good clinical evidence. Within those interventions, the ones that were also supported by studies published between January 2011 and June 2021 and offering information amenable to health economic analysis were:

- education and self-management
- education and exercise
- exercise with or without manual therapy.

There is a lot of noise, but also some clear signals

Our review of the literature indicates that there are a large number of studies on non-surgical, non-pharmacologic, guideline-informed interventions in osteoarthritis from many countries, providing good evidence of positive clinical results in terms of pain and functional outcomes.

Amongst these, a small number of well-designed, well-described studies, including several based in New Zealand and countries with comparable health systems, were identified. These allow the best understanding of how well models of care stack up against each other and against the conventional surgical and pharmacologic models of care. The longer the follow-up of studies on models of care, the more insights there are into this question.

Our review identified that:

Alternative models of care can be good for the health system…

- It is possible to achieve a favourable return on investment from non-surgical, non-pharmacologic models of care from a public health system perspective as well as a societal perspective. At least one model already trialled in New Zealand proves this to be true (the MOA (Management of OsteoArthritis) trial exercise model of care) with a favourable ROI (return on investment) from a purely public health system perspective ($1.11 per dollar invested) at 5- year follow-up, indicating that health system savings can be achieved. Any additional gains in productivity, quality of life, reduced caregiver burden would further increase this ROI.
- As demonstrated by a New Zealand joint clinic programme, successful models of care for osteoarthritis reduce GP visits, specialist visits and medication costs, and help to address unmet need. They also allow some patients to avoid surgery and some patients to delay surgery, ensuring that those who need it have timely access.
- Exercise-based models of care appear to be the most likely to provide a favourable return on investment from a public health system perspective, although in some cases, health system benefits, in particular, were related to weight loss impacts, indicating

that a weight management component may enhance the effectiveness and system affordability of exercise programmes as well as the long term impacts of interventions.

…as well as for society and patients

- Because of the high productivity costs and negative impacts on quality of life, return on investment is generally more favourable from a societal perspective, which few studies are able to fully capture, resulting in return on investment being likely to be underestimated in most published studies.
- Successful models of care also help patients to manage their weight and improve a range of health outcomes. The impacts of these on other conditions is inconsistently captured by published studies, some of which measure all health system costs, while others focus only on OA-related costs. Impacts on other conditions may also be longer term and unable to be captured within the timeframe of most OA studies. This means that return on investment may be underestimated from both a health system and societal perspective.
- The MOA exercise model of care was associated with a societal return on investment of $13.52 per dollar invested. Excluding the value of QALYs (quality-adjusted life years), the societal return on investment from this model of care is still $6.72 per dollar invested due largely to the impact on productivity and informal care.

These models of care can support the health system to achieve its goals

The themes of sustainability and person and whānau-centred care that feature strongly in the April 2021 Health Reform White Paper requires the system to ensure *"everyone can access a wider range of support to stay well in the community, with more services designed around people's needs and which better support self-care"*. Our findings indicate that alternative models of care for OA:

- can offer improved health outcomes at no additional cost to Vote Health over a 2 or more year investment
- reduce the significant private cost burden of OA on New Zealanders
- would be equity-enhancing due to the significant costs of OA that are currently borne by patients through privately funded care and productivity losses, both of which people on low incomes cannot afford
- reduce demand for surgery and GP, addressing serious demand pressures that are currently contributing to unmet need.

Carefully designed exercise-based programmes warrant greater investment

In light of these findings, we recommend:

- Improved access to cost-effective, exercise-based interventions (with additional core treatments as appropriate) in the community for people with OA who are experiencing functional limitations and/or pain and are otherwise likely to be referred for surgery.
- Improved access to weight management components for people with knee or hip OA who are overweight or obese.
- Implementation of a triage provider model to improve access to OA care, reduce pressure on the health system, and support a more patient-centred approach to OA.

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1 Background

Arthritis New Zealand commissioned NZIER to assess the evidence from published studies evaluating the impacts of non-surgical, non-pharmacologic models of care for hip and/or knee osteoarthritis (OA) to determine whether an investment case can be made to support increased investment in these models of care in the New Zealand context.

1.1 What is osteoarthritis?

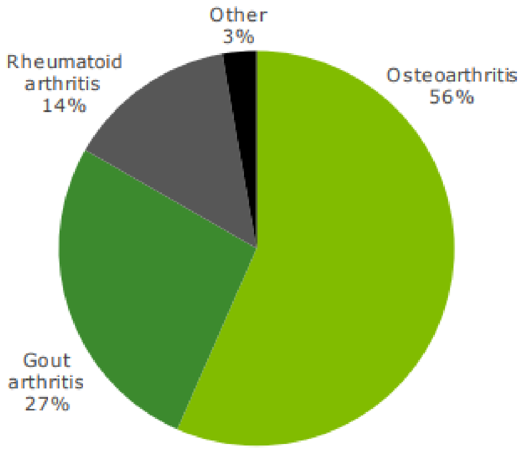
OA refers to a clinical syndrome of joint pain and functional limitation resulting in reduced quality of life:

- 80 percent of people with OA have some degree of movement limitation
- 25 percent cannot perform major activities of daily living
- 11 percent of people with knee OA need help with personal care
- 14 percent of people with knee OA need help with routine needs

(Guccione et al. 1994).

OA is the most common form of arthritis and one of the leading causes of pain and disability worldwide. Globally, osteoarthritis is the 12th highest contributor to disability, and it is the 16th highest in New Zealand (Vos et al. 2017).

Figure 1 Arthritis by type in New Zealand



Source: Deloitte Access Economics (2018)

OA predominantly affects older people and often co-exists with other conditions associated with ageing and obesity, such as cardiovascular disease and diabetes, as well as psychosocial problems (for example, anxiety, depression and social isolation) (NICE 2014).

1.2 Prevalence of osteoarthritis

Globally approximately 10–12 percent of the adult population have symptomatic osteoarthritis, and OA accounted for approximately 0.6 percent of all DALYs (disability-adjusted life year) and 10 percent of all musculoskeletal DALYs. In New Zealand, OA accounts for more DALYs – 1.85 percent. OA is the fastest increasing major health condition in terms of its years lived with disability (YLD) ranking, increasing YLDs 64 percent between 1990 and 2010 (Hunter, Schofield, and Callander 2014) due to population ageing and increased rates of overweight and obesity.

According to the Global Burden of Disease study, OA of the knee accounts for 83 percent of the total OA burden (Hunter, Schofield, and Callander 2014).

A 2017 New Zealand-based study (J. Haxby Abbott et al. 2017) estimated the prevalence of knee OA in New Zealand across age groups from 40 to 44-year-olds to 80 to 84-year-olds, for Māori and non-Māori males and females (see Table 1 below).

Table 1 Prevalence of knee OA in New Zealand

Percent of age group population

		Age group								
Ethnicity	**Sex**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**
Non-Māori	Male	1.19	4.82	4.79	6.27	6.30	11.40	11.44	12.75	12.85
	Female	0.80	4.47	4.47	10.45	10.41	16.98	16.92	21.55	21.50
Māori	Male	0.86	2.88	2.88	9.72	9.72	14.43	14.43	20.84	20.84
	Female	1.29	4.83	4.83	6.98	6.98	13.10	13.10	18.34	18.34

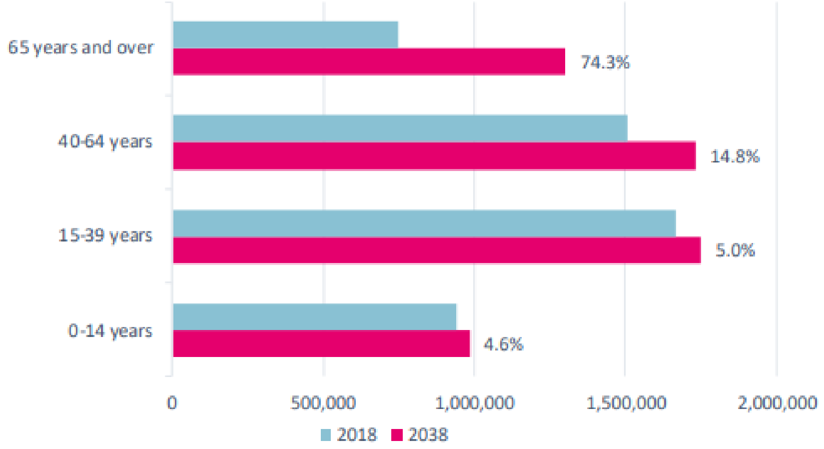
Source: Abbott et al. (2017)

Overall, one in 10 New Zealand adults – around 400,000 people – live with osteoarthritis (Ministry of Health 2016).

But with population ageing, the prevalence of OA is expected to increase. The population group aged over 65 will grow by 74 percent from 2018 to 2038 (see Figure 2 below).

Figure 2 New Zealand's ageing population

Number of people and percentage growth, projection as at 30 June 2019



Source: NZIER (2020)

1.3 The cost burden of osteoarthritis

As a major cause of disability and a major driver of demand for surgical interventions, the cost burden of osteoarthritis to the health system and New Zealand is substantial. The total annual financial cost of arthritis (including osteoarthritis) has been estimated at $4.2 billion, including:

- health system costs of $990 million
- direct productivity costs of $1.2 billion
- informal caregiver productivity costs of $1.5 billion
- expenditure on aids, equipment and modifications of $40.3 million
- services and programmes provided by Arthritis New Zealand of $1.6 million
- efficiency losses associated with transfer payments and taxation, estimated at $391 million

  (Deloitte Access Economics 2018)

Modelling of knee OA incidence, progression and health system costs indicates that the cost of treatment for knee OA alone in New Zealand is expected to reach $370 million per year by 2038, in 2013 constant prices (Wilson and Abbott 2019). The provision of total knee replacement (TKR) was projected to increase from a rate of 174 per 100,000 to 221 per 100,000, an increase of 27 percent. Continued increases in BMI were estimated to account for twenty-five percent of the cost increase and 47 percent of the TKR increase.

The rising cost burden of OA highlights the need for cost-effective management of OA and interventions that can reduce pressure on the already stretched parts of the health system by harnessing the capability of multi-disciplinary teams, including GPs specialists and allied health professionals like physiotherapists.

1.4 Clinical guidelines

Internationally, at least 17 high-quality clinical practice guidelines have been developed, and although recommendations vary somewhat across these guidelines, a major systematic review identified that exercise and education were the most strongly and commonly recommended interventions (Larmer et al. 2014).

Figure 3 Grouped interventions within osteoarthritis guidelines

Guideline	Grouped Interventions										
Organization: (Date)	Exercise	Education	Equipment	Weight Loss/ Diet	Taping, Heat/ Ice	Electrical-Based Therapy	Self-Management	Acupuncture	Manual Therapy	Psychosocial Interventions	Balneotherapy/ Spa
AAOS[17] (2008)	X	X	X	X	X		X				
ACR[19] (2012)	X	X	X	X	X	X	X	X	X	X	
BSR[21] (2005)	X	X					X				
EULAR[26] (2013)	X	X	X	X						X	
EULAR[24] (2007)	X	X	X		X	X					
EULAR[23] (2005)	X	X	X	X							
EULAR[20] (2003)	X	X	X	X							
EULAR[29] (2001)	X	X	X	X	X					X	X
NHMRC[14] (2009)	X		X	X	X	X	X	X	X	X	
NICE[1] (2008)	X	X	X	X	X	X	X	X	X		
OARSI[25] (2008)	X	X	X	X	X	X	X	X		X	
Ottawa[5] (2012)	X										
Ottawa[27] (2011)	X			X							
Ottawa[18] (2011)		X									
Ottawa[28] (2005)	X								X		
KNGF[30] (2011)	X	X			X	X	X		X		
TLAR[22] (2012)	X	X	X	X	X	X		X			X

Abbreviations: AAOS, American Academy of Orthopaedic Surgeons; ACR, American College of Rheumatology; BSR, British Society for Rheumatology; EULAR, European League Against Rheumatism; KNGF, Royal Dutch Society for Physical Therapy; NHMRC, National Health and Medical Research Council; OARSI, Osteoarthritis Research Society International; Ottawa, Ottawa Panel; TLAR, Turkish League Against Rheumatism.

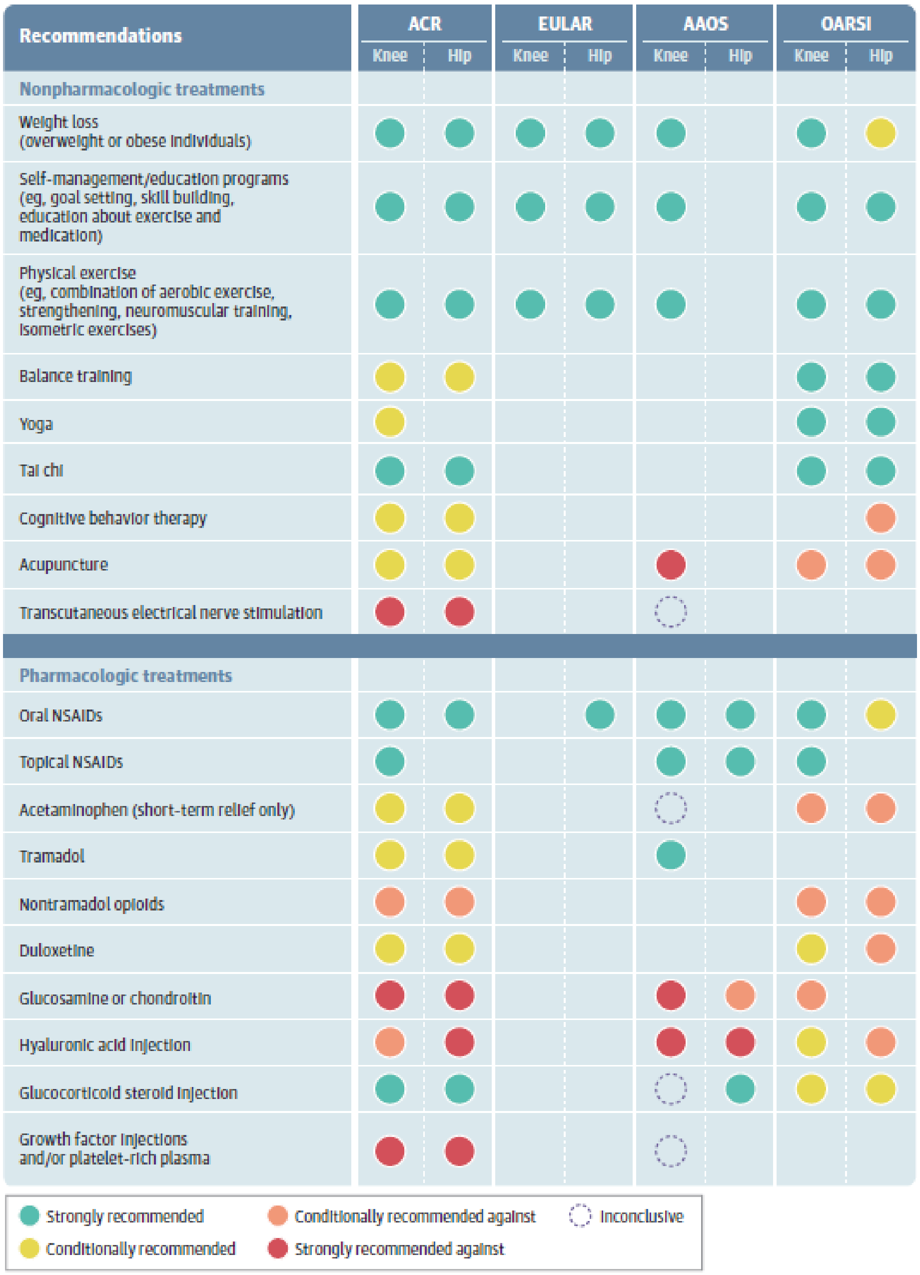
Source: Larmer et al. (2014)

Katz, Arant, and Loeser (2021) also showed that weight loss, self-management and education, and exercise are all recommended by the guidelines of:

- the American College of Rheumatology (ACR)
- the European League Against Rheumatism (EULAR)
- the American Academy of Orthopaedic Surgeons (AAOS)
- the Osteoarthritis Research Society International (OARSI).

(See Figure 4 below.)

Figure 4 Osteoarthritis treatment guidelines from major professional societies



In this figure, any recommendation with a level of evidence of 1 (out of 4) and a level of agreement of 8.5 (out of 10) or above is considered strongly recommended. Any recommendation that has moderate or limited evidence is considered conditionally recommended.

Source: Katz, Arant, and Loeser (2021)

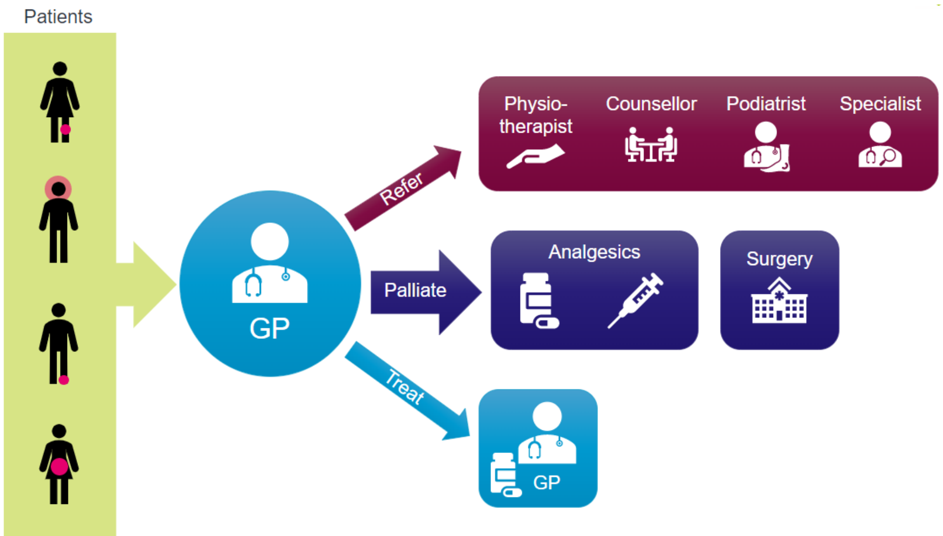
Another 2014 study (Nelson et al. 2014) suggested that the agreement of many OA guidelines indicates that there is a problem with dissemination and implementation rather than a lack of clear, high quality guidelines and recommended that efforts should be made to optimise implementation in primary care settings.

A UK study identified that uptake of guidelines could be improved with patient referral to an in-practice physiotherapy OA clinic. NICE clinical guidelines recommend that the core OA treatment should include education, exercise and weight loss (if overweight), but the management of most people with OA did not reflect the guidelines (Cottrell, Roddy, and Foster 2010). A service evaluation identified that referral to in-practice physiotherapy significantly increased the proportion of patients who received information about their condition and about weight management and exercise.

1.5 Towards new models of care

Primary care provides for the early management of osteoarthritis in New Zealand. It acts as the gatekeeper to other publicly funded services, including outpatient referrals (generally to orthopaedics with an expectation that the patient will have surgery) and pain management.

Figure 5 The current structure relies on GPs as gatekeepers



Source: NZIER

Primary care management of OA is fragmented and episodic, with little interdisciplinary collaboration. Regional inequity of access to chronic care services exacerbates these issues, as does the lack of a clear implementation strategy to support guidelines being translated into clinical practice (Baldwin et al. 2017). Consequently, primary care clinicians and researchers have called for the development of a New Zealand model of care for OA (Baldwin et al. 2017).

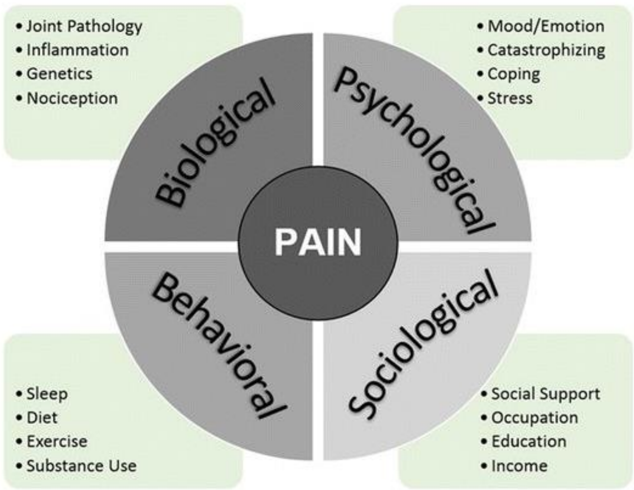
In 2021, a multidisciplinary group comprising practising health specialists, researchers from various New Zealand universities, Arthritis New Zealand and Physiotherapy New Zealand worked together in relation to this issue. The first major action of this group was to host a one-day OA Symposium or "Basecamp" at the University of Auckland in July 2021 for delegates to discuss the management and treatment of OA from a range of perspectives. This event exceeded its attendance target, with over 80 people participating, including representation from primary care, secondary and tertiary care services, and health researchers and funders. A key feature of the OA Basecamp was priority-setting workshops which all attendees participated in to start the process of co-designing a National Osteoarthritis Strategy for Aotearoa New Zealand.[1]

This work is ongoing and a follow up "OA Summit" is planned for November 2022 and will be held in Wellington. Representatives from government, the Ministry of Health and other agencies will be invited to attend and learn more about the important work being done in this space.

Three important facts that run contrary to popular belief are currently driving changes in the care of OA around the world:

- OA is not caused by ageing, so its onset and progression are not inevitable for people with OA risk factors.
- Once a person has developed OA, the condition does not necessarily continue to deteriorate leading inevitably to a need for surgery.
- A similar biopsychosocial approach to the one offered to people with accident-related chronic pain in New Zealand would also be beneficial to people with OA (Bartley, Palit, and Staud 2017; ACC 2020).

Figure 6 The biopsychosocial determinants of pain in OA



Source: Bartley, Palit, and Staud (2017)

In recognition of these facts, new non-surgical, non-pharmacologic models of care that aim to empower people with OA to manage their pain and improve function have been developed and trialled with high levels of success in clinical outcomes. But the economic case for these models of care has not yet been established.

While not all of the potential impacts of new models of care for osteoarthritis have been demonstrated, these models could impact on costs and quality of life in different ways, including:

- delaying or eliminating the need for surgery (Teoh et al. 2017, Svege et al. 2015, Skou et al. 2015, Ackerman et al. 2020)

1 Taupuni Hao Huatau Kaikōiwi Osteoarthritis Basecamp. https://events.otago.ac.nz/2021-osteoarthritis-basecamp

- improving outcomes directly through impacts on the progression of osteoarthritis and its effects on physical function or improving patients' ability to manage pain
- improving the risk and outcomes of comorbidities with similar biopsychosocial determinants, particularly for models of care that have exercise and diet components.

The latter effect was not identified in any study that we found. However, many did identify weight loss as an outcome of education, lifestyle advice, dietary and exercise interventions. Hence, it is possible that the full range of impacts is not yet understood.

Early evidence (too old for inclusion but highly supportive of this report's conclusions) indicating potential cost-effectiveness of non-surgical, non-pharmacologic models of care includes:

- Cochrane, Davey, and Matthes Edwards (2005), a health economic study alongside a randomised controlled trial of water-based therapy for lower limb osteoarthritis. This study found that a short-term water-based exercise programme could be effective in reducing pain with a favourable cost per QALY in the UK context.
- Richardson et al. (2006), a health economic study associated with a clinical trial assessing the effectiveness of a class-based exercise intervention for people with knee OA. This study demonstrated that a class-based exercise intervention delivered in addition to home-based exercise not only increased QALYs but reduced health system costs.
- Sevick et al. (2000), a study describing an RCT including a health economic evaluation of exercise interventions for older people with knee OA. This study found that, compared with education alone, exercise programmes are cost-effective, with resistance training offering slightly better value for money than aerobic training.
- Segal et al. (2004) a meta-analysis using a transfer to utility technique to translate disparate clinical outcomes reported in published studies to compare results in terms of health-related quality-of-life and cost-effectiveness. This study found that highly cost-effective interventions included THR, TKR, exercise and strength training for knee OA, knee bracing, and the use of capsaicin or glucosamine sulfate.

1.6 New Zealand-based models of care offer good evidence

Previous New Zealand-based models of care have been trialled and have demonstrated positive impacts. Three that warrant particular attention are the MOA (Management of OsteoArthritis) trial, the Joint Clinic, and the Mobility Action Programme (MAP). In addition, evaluations of adjunct interventions in the New Zealand context provide strong evidence that non-surgical, non-pharmacologic interventions may involve a range of options in patients for whom core interventions fail to deliver satisfactory results.

1.6.1 The MOA trial

The Management of Osteoarthritis (MOA) trial aimed to investigate the incremental effectiveness and cost-effectiveness of an exercise therapy programme with or without a manual therapy programme, delivered in addition to usual medical care, compared to usual medical care alone for people with hip or knee OA. The MOA programme involved all participants attending seven individualised exercise physiotherapy sessions (approximately

50 min each) over nine weeks, followed by two 'booster' sessions at weeks 16 and 54 (J. H. Abbott et al. 2019).

The MOA trial, which has generated 1 year (Pinto and Abbott 2011), 2-year (J. H. Abbott et al. 2019) and 5-year (J. Haxby Abbott, Wilson, and Pinto 2019) results, indicates that the exercise physiotherapy intervention, the manual therapy intervention and the combined intervention are all cost-effective at a QALY value equal to GDP per capita. All three physiotherapy interventions delivered clinically significant QALY gains compared with usual care, with exercise therapy producing the largest gain (0.15 QALYs over 2 years) as well as being associated with both health system and societal savings. At five years, the exercise intervention remained cost-effective relative to usual care and lifetime simulation based on observed results indicate that cost-savings and health gains would be sustained.

While the full 5-year health economic results of the MOA trial are yet to be published, according to a simulation study, the longer time horizon has allowed all three interventions (exercise, manual therapy and combined exercise and manual therapy) to demonstrate cost-effectiveness (J. Haxby Abbott, Wilson, and Pinto 2019) and shows that, contrary to common assumption, the treatment impacts of exercise therapy do not diminish over time.

1.7 The Joint Clinic programme

The Joint Clinic programme was developed by Southern DHB to address significant unmet need for secondary consultation for patients with hip and knee OA. A clinical service of Dunedin Hospital's Orthopaedic Outpatient Department, the Joint Clinic aimed to support the Ministry of Health objective of better, sooner, more convenient care by improving the management of hip and knee OA with a stronger primary and secondary care interface, involving multidisciplinary collaboration for coordinated, patient-centred care. The programme involved patients who had been referred to the orthopaedic department being assessed by advanced competency physiotherapists and the delivery of an exercise physiotherapy intervention. Over two years of operation, 637 patients visited the Joint Clinic.

An evaluation of the Joint Clinic programme (J. Haxby Abbott et al. 2019) found that the programme was associated with adherence to the concept model, high levels of both patient and staff acceptance of and confidence in the programme and its staff, and timely completion within budget. Unmet need (measured as referrals returned to GP) was measured as reduced by 90 percent and both patient and referring clinician overall satisfaction was reported as being high.

The joint clinic demonstrated that the health system could offer another option for the management of hip and knee OA based on a multidisciplinary approach, using advanced competency physiotherapists to help meet the high and rising demand for care, with the support of GPs and specialists.

1.7.1 The Mobility Action Programme (MAP)

In Budget 2015 $6 million of new funding was allocated to improving care for people with musculoskeletal conditions, including oseoarthritis. The funding aimed to increase access to early community-based advice, treatment, education and self-management, and rehabilitation.

The Mobility Action Programme (MAP) was a Ministry of Health initiative designed to test best practice community-based, multidisciplinary early intervention programmes for musculoskeletal conditions. The MAP funded a range of programmes with the goal of improving quality of life and reducing the need for surgery. Models of care that are found to provide the greatest benefits for people with musculoskeletal conditions while providing good value on the investment in health resources are expected to be translated into larger scale and sustainable publicly-funded services (Ministry of Health 2021).

Between May 2016 and December 2019, the MAP had 4,783 participants in total, with high representation from Māori and Pacific people and people living in high deprivation areas. A programme evaluation based on this period (Allen +Clarke 2021) indicates that participation in the MAP contributed to:

- sustained reduction in Body Mass Index (BMI)
- significant improvement in health-related behaviour
- significant reductions in pain
- improvements in mobility and functionality
- significant improvement in participants' confidence to self-manage their conditions
- significant improvement in general health and wellbeing
- significant reductions in visits to specialists and other secondary health services.

The evaluation revealed that the MAP's most significant system impact was in reducing GP visits and diagnostic tests. The programme was associated with a cost per participant of $743 and was projected to be cost-effective over a 5-year time horizon.

The MAP was funded for three years (2015/2016, 2016/17 and 2017/18 financial years) with a view to continued funding of successful models, rolled out on a larger scale through sustainable, publicly-funded services (Ministry of Health 2021).

1.8 Adjunct interventions

No single intervention provides adequate symptom relief for all patients. In some cases, however, additional interventions can significantly improve the effectiveness of a first non-surgical, non-pharmacologic intervention at a cost that offers good system value.

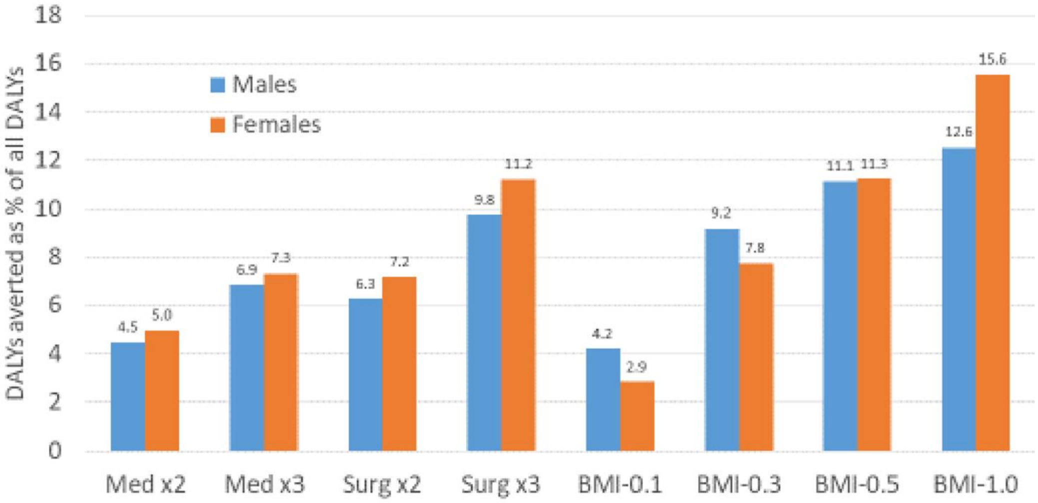
A 2020 study (Wilson et al.) also indicates that within a New Zealand health system context, water-based exercise and other therapies (including walking cane and heat therapy, which were both found to be cost-saving and aquatic exercise and intra-articular corticosteroids) were cost-effective adjunct interventions for people whose knee OA symptoms persisted after receiving core treatments including education, land-based exercise and weight loss, with the cost per QALY gained under New Zealand's GDP per capita. These interventions could provide a cost-effective way of further delaying or preventing the need for surgery.

A 2017 systematic review (Woods et al. 2017) pooled together data from 88 randomised controlled trials including over 7,500 patients to evaluate the cost-effectiveness of alternative adjunct non-pharmacological treatments for knee osteoarthritis. It found that transcutaneous electrical nerve stimulation (TENS) offered as an adjunct intervention to usual care is associated with a favourable incremental cost-effectiveness ratio relative to usual care alone.

A 2021 study (Pryymachenko et al. 2021) found that at a 2-year follow-up after an effective 9-week exercise intervention for people with knee OA, the provision of booster sessions including exercise therapy or manual therapy was cost-effective from a health system and societal perspective.

Another 2021 study – a Canadian microsimulation study (Kopec et al. 2021) – found that when impacts are modelled over a longer time horizon, interventions that achieve significant weight loss produce a more significant impact on DALYs lost than surgical and pharmacologic interventions (see Figure 7 below).Weight loss and weight management interventions can be delivered as part of a multi-disciplinary OA intervention through diet, exercise, education or a combination of these, or in addition to other core treatments.

Figure 7 DALYs averted by medical, surgical and BMI-reducing interventions



Source: Kopec et al. 2021

2 Our approach

This report is based on a focused literature search rather than a systematic review of the literature.

An initial literature search during which study abstracts only were extracted established that a large number of non-surgical interventions have been tested and report a range of outcomes in a range of contexts, using various combinations of education, aerobic exercise, neuromuscular exercise, self-management, dietary interventions for weight loss, cognitive behavioural therapy, coping skills, manual therapy, mind-body exercise, land-based exercise, water-based exercise, etc.

In consultation with Arthritis New Zealand and Professor David Hunter, a leading rheumatology clinician researcher based at the University of Sydney, the list of interventions for inclusion in this report was narrowed to include combinations of muscle strengthening, land-based exercise, dietary interventions, and education and self-management, consistent with the many guidelines published on the care of osteoarthritis.

The next stage was to obtain full-text versions of all the relevant studies and to systematically identify what information these could offer that could inform an investment case for a non-surgical, non-pharmacologic model of care. We sought to include only studies published in the last ten years – from 2011 to 2021. The reason for this being the considerable uncertainty associated with inflating health system and other costs over longer periods of time. Several older studies have been included for context, but the return on investment and cost-effectiveness of interventions is estimated based on recent studies only.

At this stage, it became evident that much of the published research establishes positive clinical outcomes of these models of care but does not offer information on costs, cost impacts, or outcomes that are amenable to valuation. Consequently, the focused list of interventions was further narrowed based on the availability of health economic evidence. This resulted in the following groupings for models of care:

- education and self-management interventions
- exercise interventions with or without manual therapy
- education and exercise interventions.

Education is a basic component of most models of care for OA, including the usual GP care that most patients receive. So, for this report, unless the design of the education component was typically not substantially different from the expected education component associated with the 'usual care' comparator, the intervention was not classed as an education-based model of care.

The studies are listed in table form in Appendix A. To provide an easy-to-understand assessment of studies, each study is rated according to the demonstrated value of the intervention and according to the level of confidence with which impacts, and values might be expected to apply in the New Zealand context. A simple traffic light system for each rating is reflected in the colouring of the evidence tables (see tables below).

Table 2 Value rating

Rating	Rationale
Cost-effective	Intervention is cost-effective from a health system perspective and a societal perspective up to the Value of a Statistical Life (VoSL)-based value of a QALY in the 2022 Treasury CBAx[2] model impacts database.
Potentially cost-effective	Intervention is not cost-effective at Treasury CBAx value of a QALY but is cost-effective at a QALY value equal to GDP per capita or is cost-effective from only a health system or societal point of view but not both.
Not cost-effective	Intervention cost-effectiveness was not demonstrated at either possible QALY value.

Source: NZIER

In addition to a value rating, the tables in the appendix are colour-coded to reflect a confidence rating on the applicability of results to the New Zealand context.

[2] The CBAx tool is a spreadsheet model that contains a database of values to help agencies monetise impacts and do cost benefit analysis.

Table 3 Confidence rating

Rating	Rationale		
High	New Zealand, Australia or UK-based study	AND	High quality study, clear intervention, clear and robust methodology
Medium	Canada or Europe-based study	AND	High quality study, clear intervention, clear and robust methodology
Low	All other countries	OR	Low quality study, unclear intervention, inappropriate comparator, unclear or weak methodology

Source: NZIER

The implications of the results of studies are discussed in section 4, which provides 2021 New Zealand dollar values and estimates of return on investment from the public health system, total health system, societal (excluding QALYs) and societal (including QALYs) perspectives, based on the findings of the studies reviewed.

2.1 2021 New Zealand dollar values

Where the implications of results of overseas studies for New Zealand are unclear from the reported results (for example, interventions are reported to be cost-effective at a specified amount in foreign currency), values reported are converted into 2021 New Zealand dollars by first converting values using OECD Purchasing Power Parities (OECD n.d.) for the appropriate year and then inflating to 2021 using the Treasury CBAx tool.[3] This allows for interventions that may be judged as cost-effective in other jurisdictions to be assessed using New Zealand values.

Costs of interventions and the value of impacts as represented by health system and non-health system costs can change significantly over time. The application of GDP inflators, as used in the CBAx tool to adjust values from previous years, or indeed any general approach to inflating past prices results in increasingly uncertain estimates as the time horizon increases. This is the reason for limiting the literature search to studies published no earlier than 2011.

2.2 New Zealand QALY values

We have assessed the cost-effectiveness of interventions using the Treasury CBAx values for a QALY, of which there are two in the 2022 version of the CBAx model's impacts database:

- a value of $36,363 per QALY, based on Pharmac evidence
- a value of $59,897 per QALY, based on the Value of a Statistical Life (VoSL).

Although the Treasury encourages the use of the lower of these two values for the evaluation of health interventions, it is important to note that this value is derived from the average QALY return from Pharmac investments. This means that many investments involving a higher cost per QALY are nevertheless publicly funded. Indeed, the lower value indicated by the CBAx model impacts database sets a high bar, particularly for non-

[3] https://www.treasury.govt.nz/information-and-services/state-sector-leadership/investment-management/plan-investment-choices/cost-benefit-analysis-including-public-sector-discount-rates/treasurys-cbax-tool

pharmacologic interventions, which would not benefit from Pharmac's commercial procurement strategies that have been widely credited for keeping pharmaceutical costs low. The value is also low by international standards:

- Many studies refer to gross domestic product (GDP per capita) as an appropriate value for a QALY. In New Zealand, in 2021, that would be approximately $69,829 per QALY.
- The National Institute for Health and Care Excellence (NICE) has been using a threshold of £20,000 to £30,000 per QALY in decisions about the cost-effectiveness of new health technologies since the early 2000s without inflation adjustment. This threshold is currently under review. The NICE range is equivalent to approximately NZ$41,000 to $61,000. However, NICE does sometimes approve interventions where the cost per QALY exceeds the threshold range based on other considerations.
- In the United States, the Institute for Clinical Economic Review (ICER) currently values a QALY at USD50,000 to 150,000. This range is equivalent to approximately NZ$73,000 to $219,000.

2.3 Return on investment

Return on investment (ROI) is a key consideration in public spending decisions. Occasionally, interventions may provide a favourable return on investment from a purely health system perspective when they result in downstream savings to the health system, such as if costly surgery is avoided. However, health system spending does not generally result in a favourable return on investment from a purely health system perspective. This is due to the primary benefit of most health interventions being quality of life for the patient rather than health system savings.

For some conditions, people tend to use a lot of privately funded care (in the OA case, this would likely be physiotherapy due to this not being offered through the public system, but could also include dietitian care or items like supplements that they believe will help them manage symptoms). Consequently, the public system's failure to provide what patients actually need will effectively distort the ROI because it is impossible to save much in areas where there is little to no spending.

When ROI from a societal perspective is considerably higher than ROI from a public health system perspective, this may be due to:

- the condition being associated with high levels of patient out-of-pocket expenditure
- the condition imposing a heavy burden on informal caregivers
- the condition causing high avoidable productivity losses
- the condition being associated with high, negative and avoidable quality of life impacts.

Return on investment from a societal perspective provides the best indication of value for money for publicly funded investments and should be the primary indicator used to identify worthwhile investments. However, when decisions are being made within a fixed health system budget, return on investment from a health system perspective provides information about the affordability of the investment: Where a favourable return on investment is expected, the intervention produces savings to the system and can effectively pay for itself.

For this reason, we report two return on investment results based on the two common perspectives of health economic evaluations:

- return on investment from a health system perspective
- return on investment from a societal perspective.

Return on investment is presented as a ratio of gross returns per dollar invested. For example, an intervention with a public health system ROI of $1: $1.50 will return $1.50 in savings to the health system for every dollar invested.

3 The investment opportunity

The greater the costs associated with a health condition, the greater the potential savings from cost-effective interventions.

3.1 Total costs

A large number of studies have identified the significant costs of osteoarthritis. However, the range in cost estimates is wide and creates considerable uncertainty:

- Hunter, Schofield, and Callander (2014) note that OA studies from the US, Canada, UK, France and Australia have produced estimates of the cost of osteoarthritis at between 1 percent and 2.5 percent of GDP. Based on projected nominal GDP for 2021 of $346 billion (NZIER 2021), and even without taking into account possible increased prevalence, the estimated cost of osteoarthritis in New Zealand would be $3.46 billion to $8.65 billion in 2021.
- A 2015 systematic review of cost-of-illness studies (Puig-Junoy and Ruiz Zamora 2015) identified that because of the wide range of approaches and methods used, the estimated average total annual cost per patient and the estimated average incremental annual cost per patient were €4257 and €4175 respectively for knee osteoarthritis and €6525 and €15,499, respectively for hip osteoarthritis (2011 euros). That study concluded that the social cost of osteoarthritis is likely to be between 0.25 percent and 0.50 percent of a country's GDP (NZ$865 million to $1.73 billion).

Because the estimated cost of a condition is largely related to the prevalence of the condition, the services offered to address the condition, access to those services, and the availability of good quality data, a wide range of estimates internationally is not surprising. But another major driver of wide variation in cost estimates is the range of approaches taken to value societal costs for which, unlike health system costs, there are no readily available data. The latter is the primary reason for wide variation in costs for a single country, as well as internationally. This is also typical for social and economic impact studies of health conditions where alternative valuation techniques are expected to produce different results, but no single valuation technique can be confirmed as more appropriate.

3.2 Direct health system costs

Generally, health system costs tend to be better reflected in studies than other costs due to researchers having better access to cost and utilisation data. As a result, these are the most reported costs and the most consistent in value:

- A 2010 report on the economic costs of arthritis in the UK (Oxford Economics 2010) indicated that direct health costs account for only 20 percent of total costs.

Figure 8 Annual arthritis costs, UK 2008

Cost Category	Arthritis costs (OA and RA, £ billion)	Percentage of total (%)
Direct Costs	**6.1**	**20**
Hospital and other health costs	6.1	20
Indirect Costs	**14.8**	**48**
Individuals unable to work	10.0	33
Absenteeism	0.6	2
Reduced productivity	3.3	11
Informal Carers	0.9	3
Quality of life costs	**9.8**	**32**
Value of healthy life lost	9.8	32
TOTAL COSTS	**30.7**	**100**

Source: Oxford Economics, (2010)

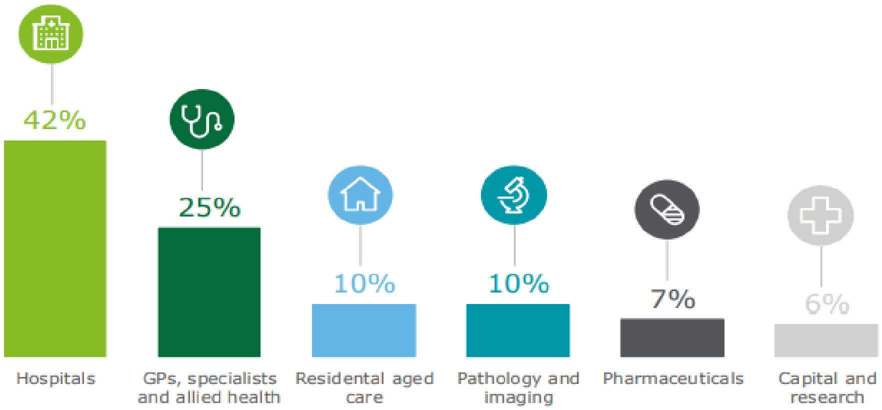
- According to Pinto and Abbott (2011), the total annual health system costs attributable to OA in New Zealand were estimated to be $555 million in 2010 and are expected to be rising rapidly with population ageing. This figure is valued at approximately $854 million in 2021 – approximately 0.25 percent of GDP – without accounting for increased prevalence.
- Baldwin et al. (2017) report that in New Zealand, health sector costs of arthritis overall are estimated at $695 million annually based on 2010 values. This figure would be worth over $1 billion in 2021 – around 0.3 percent of GDP – without accounting for increased prevalence.

A 2018 report (Deloitte Access Economics 2018) using New Zealand data estimated that the direct health sector costs of arthritis in 2018 amounted to nearly $1 billion – around 0.3 percent of GDP. This figure would be worth approximately $1.03 billion in 2021 without accounting for increased prevalence.

The same report estimated that hospital inpatient costs account for around 42 percent of health sector costs, with GP, specialist and allied health visits at 25 percent and other health system costs accounting for 10 percent or less each (Deloitte Access Economics 2018). This finding is likely to be driven by OA, which is the most common form of arthritis. OA of the hip and knee is the most common condition for which joint replacements are performed in New Zealand (Hooper et al. 2014).

Over 8,000 hip and 7,000 knee replacements were performed in 2015 (Baldwin et al. 2017). A study based on data from the New Zealand Joint Register from 2001 to 2011 (Hooper et al. 2014) provided projections for total hip replacement (THR) and total knee replacement (TKR) to 2026, with these figures expected to increase 84 percent and 183 percent, respectively, by 2026. These estimates have been independently confirmed by leading OA researchers (Wilson and Abbott 2019). A value for 2021 was estimated using linear interpolation based on the study's estimates for 2001 and projections for 2026. This indicates that in 2021, approximately 8,135 THRs and 7,500 TKRs are expected to be performed.

Figure 9 Breakdown of direct arthritis costs, New Zealand



Source: Deloitte Access Economics (2018)

The range of estimates indicate that the direct health system costs of osteoarthritis in New Zealand are highly likely to be over $1 billion in 2021 – over four percent of Vote Health 2021/2022 and more than the total cost of the 2021/22 COVID-19 public health response (The Treasury 2021).

This estimate is consistent with a previously published estimate of US direct health system costs of OA, which indicated it accounts for 4.3 percent of all health system costs. (Torio and Moore 2006). That study placed osteoarthritis amongst the five most costly conditions/events managed in hospitals, along with septicaemia, liveborn (newborn) infants, complication of device, implant or graft, and acute myocardial infarction.

Based on approximately 400,000 people living with OA in New Zealand, the average direct health system cost of OA per person is approximately $2,500.

3.3 Other financial costs

Direct costs outside the health system and indirect costs are more challenging to quantify. But some estimates provide a sense of scale:

- Schofield et al. (2015) estimated the lost productive life years of Australians with chronic conditions. That study found that arthritis is one of the leading conditions associated with premature exit from the labour force, responsible for 13.26 percent of productive life years lost to chronic conditions. In total, 9.47 percent of GDP was lost to chronic conditions as a result of lost productive life years. If arthritis is responsible for 13.26 percent of this figure, then 1.25 percent of GDP is lost due to the productivity impacts of arthritis.
- Pinto and Abbott (2011) indicate that the value of lost productivity and other indirect financial impacts are estimated to be around $2.1 billion in 2010 – approximately $3.2 billion in 2021 or one percent of GDP, without accounting for increased prevalence.
- A 2018 report (Deloitte Access Economics 2018) on the costs of arthritis (including osteoarthritis as well as rheumatoid arthritis and gout) found that non-health sector financial costs were over three times as high as the health sector costs of arthritis. The productivity loss of people with OA is estimated at $1,858 per person ($1.2 billion in total – or 0.4 percent of GDP) due to reduced employment, absenteeism and

presenteeism and is borne roughly equally by individuals, employers and government. The same study estimated that additional productivity losses associated with informal care are estimated at $2,311 per person ($1.5 billion in total – or 0.5 percent of GDP) due to nearly 12 hours of informal care per week per person. As a result, approximately 0.9 percent of GDP is estimated to be lost to lost productivity.

- The above estimates are consistent with findings by Gupta et al.(2005) that 52.1 percent of OA indirect costs are related to caregiving, but this cost is rarely included in economic evaluations of interventions in OA.
- Losina et al (2019) report that knee OA pain leads to USD$1,037 per person in lost productivity annually. This lost productivity is increased in the year of either primary or revision TKA, to $3,311 and $3,592, respectively, indicating that the association between surgery and productivity in the working-age population warrants increased attention.

Overall the range of figures for lost productivity indicates anywhere from 0.5 percent of GDP to 1.25 percent of GDP could be lost due to reduced employment, absenteeism, presenteeism, and lost income for people with OA and their informal caregivers.

3.4 Quality of life

A major impact of OA and, therefore, the potential for interventions to deliver individual-level impact is the loss of QALYs. Abbott et al. (2017) estimated the population-based QALY losses due to knee OA in New Zealand. On average, the study found that knee OA accounts for 3.44 QALYs lost per person, and a total of 467,240 QALYs across the adult population, based on NZ EQ-5D health state valuations (see Table 4 below).

Table 4 QALY losses due to OA

Based on knee OA

	Non-Māori male	Non-Māori female	Māori male	Māori female	Total population
Weighted QALE in people with no OA	19.73	21.96	17.57	19.78	20.67
Weighted QALE in people with OA	12.20	12.22	10.05	12.17	12.14
Weighted QALE if people with OA didn't have OA	15.54	15.77	12.64	15.55	15.57
QALY loss per person with OA	**3.34**	**3.55**	**2.60**	**3.38**	**3.44**
Population-based QALY losses	**166,023**	**272,568**	**11,562**	**17,087**	**467,240**

QALE: Quality-adjusted life expectancy
Source: Abbott et al. (2017)

Based on a loss of 3.44 QALYs per person with OA, the undiscounted value of lost QALYs per person with OA is $110,968. Across the entire population, that amounts to an undiscounted value of over $15 billion.

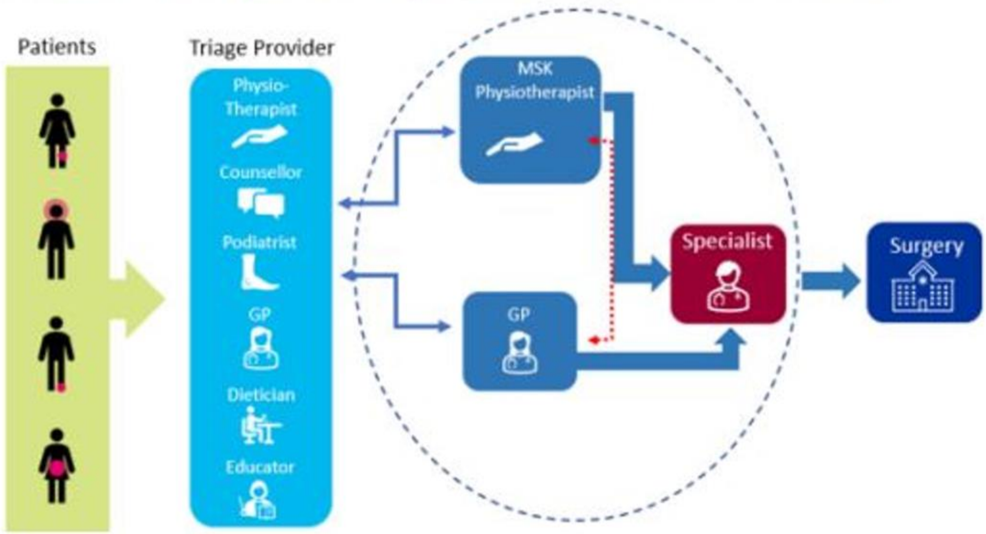
3.5 System level value

A critical concern for health planners is that decision-making about investment in health interventions should not take place in a vacuum. While information on the return on investment associated with an intervention, its direct and indirect costs, and even its quality-of-life impacts are important, all interventions must fit the broader health system and offer a sustainable solution to health problems.

The health and disability system is currently under a high degree of pressure due to increasing rates of long-term conditions, an ageing population and the system's failure to invest adequately in the workforce, information technology, and new models of care to be able to keep up with demand. General practitioners (GPs) and specialists report being unable to support rising levels of demand, and yet the standard models of care require patients to access a GP first for a referral, with the highest volumes of referrals being to specialist services.

Pharmacologic and surgical management of osteoarthritis reinforces the existing patient flows and access issues in the health and disability system (Abbott J. et al. 2022). Alternative models of care, on the other hand, are often led by physiotherapists and delivered by allied health teams with minimal input from GPs and specialists (see Figure 10 below). These models have been shown to reduce GP and specialist visits overall, freeing up scarce clinical workforce for other needs, and by delaying or avoiding the need for surgery, alternative models of care for osteoarthritis also free up valuable operating theatre and hospital bed capacity.

Figure 10 Triage system access to practitioners for OA patients



Source: Allied Health Aotearoa New Zealand (AHANZ) 2021, adapted from NZIER 2019

While monetisation of this system-level value is outside the scope of this report, the value of improved access to primary care, specialist care, operating theatre capacity and hospital bed capacity should be considered in terms of the potential benefit that could be obtained from this in providing improved access to services for other patients as well as improved workforce and service sustainability.

4 The evidence for investment

Few of the studies reviewed for this report provided sufficient detail to identify return on investment from a public health system perspective, total health system perspective and societal perspective; however, the small number that did and the implications for return on investment are described in this section.

4.1 Direct evidence of return on investment

Walker et al. (2017) undertook a societal return on investment (SROI) analysis of a physiotherapy-led service for managing osteoarthritis in primary care consistent with the UK's National Institute for Health and Care Excellence (NICE) guidance and showed that in the UK, based on conservative values and accounting for deadweight, displacement effects, drop-off, and attribution, this model of care provides a return of £2.43 to £4.03 in social value per £1 invested. This was attributable to:

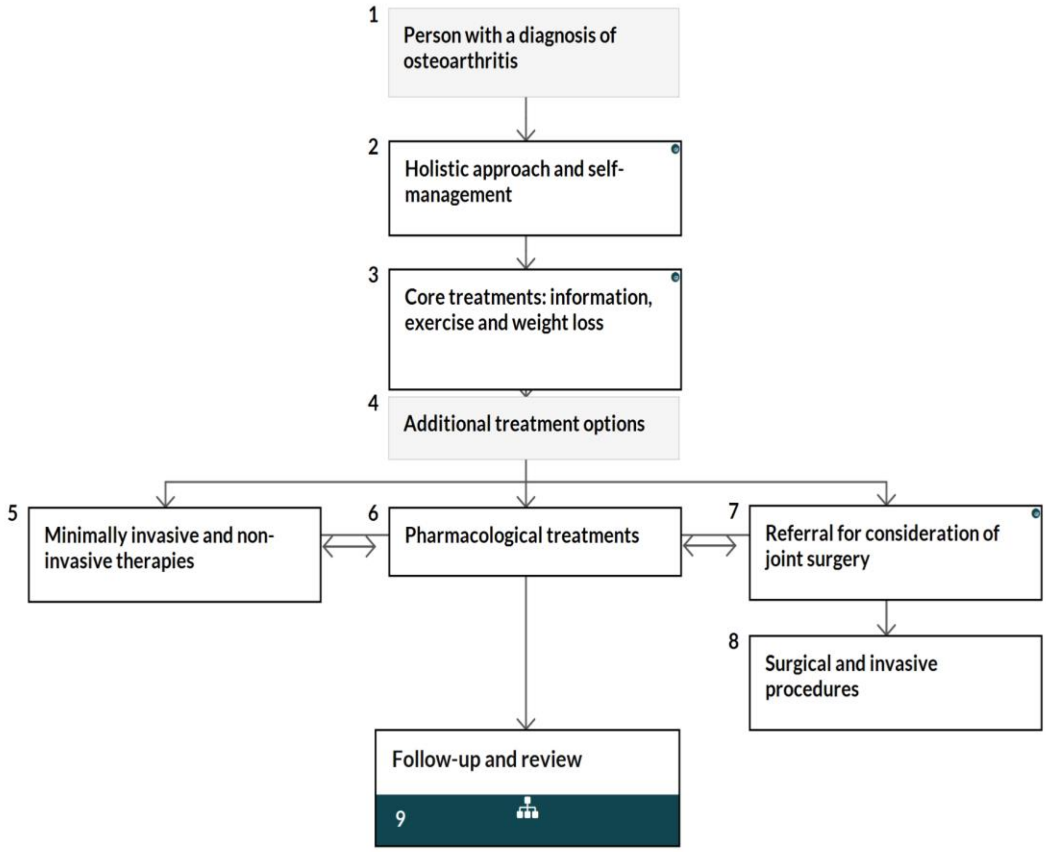
- reduced health system utilisation (fewer GP visits and secondary care referrals for osteoarthritis) and health system savings as a result of weight loss
- savings for patients from reduced time spent travelling to and accessing a GP
- improved quality of life for patients resulting from increased levels of physical activity, improved physical and mental health, reduced pain.

Table 5 Implications of direct evidence on return on investment

Study	Model of care	Reported return on investment	Implications (NZ$, 2021)	Key results
(Walker et al. 2017) UK (£)	NICE guidelines-based physiotherapy-led intervention in primary care	£2.43 to £4.03 in social value per £1 invested.	Societal ROI. $1:$2.43 to $4.03 with both health system and private benefits	High confidence Cost-effective intervention Similar health system Guidelines-based replicable intervention

The NICE guidance on the management of osteoarthritis indicates that a holistic approach with self-management should be the first-line treatment, followed by core treatments including information, exercise and weight loss before considering additional treatments or joint surgery (see Figure 11 below).

Figure 11 NICE guidance for management of osteoarthritis

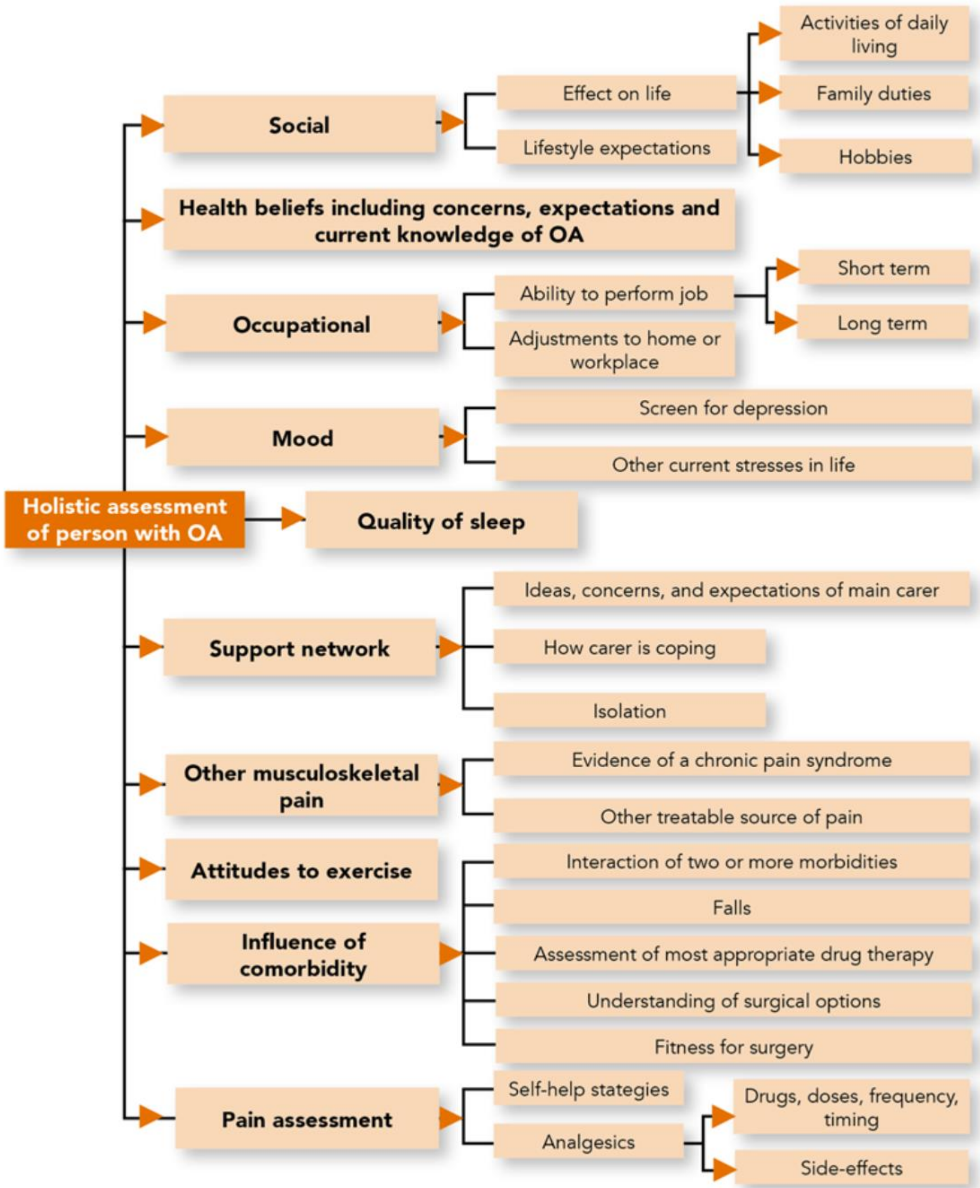


Source: NICE 2021

The NICE also propose a specific algorithm for the holistic assessment of a person with OA (see Figure 12 below), which includes discussing the risks and benefits of treatment options and offering advice on:

- access to information relevant to the patient’s condition
- activity and exercise
- Interventions to achieve weight loss if the person is overweight or obese.

Figure 12 NICE algorithm for holistic assessment of a person with osteoarthritis



Source: NICE 2020

The NICE guidance on education and self-management (NICE 2020) focuses on:

- offering information to enhance the person's understanding of osteoarthritis and its management in an ongoing way and as an integral part of the management plan rather than as a one-off
- agreeing individualised self-management strategies based on behavioural change (exercise, weight loss, suitable footwear and pacing) with an emphasis on core treatments, especially exercise
- considering the use of local heat or cold as an adjunct to core treatments.

The guidance specifically recommends that referrals for joint surgery should not be made until the person has been offered at least the core non-surgical options.

4.2 Direct health system cost impacts

As noted in section 3, the range of estimates indicates that the direct health system costs of osteoarthritis in New Zealand are highly likely to be over $1 billion in 2021.

This implies a per person direct health system cost of osteoarthritis of approximately $2,500, but studies may generate cost savings that appear out of proportion to this amount. This could be due to methodological flaws, different contexts and baseline costs, or the fact that participants in clinical trials of new models of care for OA are frequently recruited from patients with chronic pain that is not new, patients on waitlists or who have been referred for surgery, and patients who are overweight or obese or over a minimum age.

Consequently, patient groups in trials may represent those with higher than average OA costs. The most comprehensive accounting for costs in the studies reviewed for this report was in the J. H. Abbott et al. (2019) and Pinto et al. (2013) studies, both of which were based on the MOA trial, and both of which confirm that patients involved in trials have 'usual care' costs that are higher than the average OA cost per person suggests:

- J. H. Abbott et al. (2019) found that the public health system costs of people randomised to the control arm of the MOA trial were $7,410 over 2 years, or $3,705 ($5,921 in 2021) per year. In addition, there was a $932 ($1,490 in 2021) private health system cost per year.
- Pinto et al. (2013) estimated costs associated with the MOA trial at 1-year follow-up and found usual care public health system costs of $3,207 ($5,126 in 2021) and private health system costs of $724 ($1,157 in 2021).

These baseline costs are important to bear in mind when considering the size of cost impacts.

Table 6 below describes the direct cost impact implications that can be confidently drawn from the studies reviewed.

Table 6 Implications of direct cost impacts

Based on included studies

Study	Model of care	Reported cost impacts	Implications (NZ$, 2021)[1]	Key results[1]
Ackerman et al. (2020) (AUD 2019)	Multi-disciplinary intervention including exercise, education, insoles, dietary advice and pain medication for people with knee OA	Intervention cost $750-$3,000	Intervention cost $757 - $3,028	

Study	Model of care	Reported cost impacts	Implications (NZ$, 2021)[1]	Key results[1]
Bennell et al. (2012) Australia (AUD 2012)	Exercise with pain, education and coping skills	Intervention cost $1,065	Intervention cost $1,456	Not cost-effective Insufficient information for ROI
Hurley et al. (2012) UK (£)	ESCAPE-knee pain exercise programme	Intervention cost +£224 pp	Intervention cost approx. $1,008 Health system savings approx. $1,375 Health system ROI. $1:$1.36	High confidence Cost-effective intervention Longer than usual follow-up (30 months)
York Health Economic Consortium (2017) UK (£)	ESCAPE knee pain exercise programme	Intervention cost +£312 Health system -£1,310 Health system ROI: £1:£5.20	Intervention cost approx. $650 Health system savings in NZ approx. $2,737	Cost-effective intervention Health system savings and ROI are high due to social care cost inclusion.
J. Haxby Abbott et al. (2019) New Zealand (NZD 2009)	Joint clinic to manage unmet need	Intervention cost approx. $550 (1st yr), $384 (2nd yr)	Intervention cost approx. $550, $384 Reduced declined FSAs in 40% of patients. Insufficient information for ROI	High confidence New Zealand-based study Insufficient information for ROI
J. H. Abbott et al. (2019) New Zealand (NZD 2009)	MOA exercise only	Intervention cost: $503 Public health system cost: -$559 Private health system cost: -$879	Intervention cost: $804 Public health system savings $893 Private health system savings $1,405 Public health system ROI: $1:$1.11 Total health system ROI: $1:$2.86	High confidence New Zealand-based study Effective and cost-saving intervention (public health system, total health system) 2 year follow-up Favourable ROI (public and total health system)
J. H. Abbott et al. (2019 New Zealand (NZD 2009)	MOA manual therapy only	Intervention cost: $486 Public health system cost: +$1,637 Private health system cost: -$1,111	Intervention cost: $777 Public health system savings -$2,616 Private health system savings $1,776 Public health system ROI: Unfavourable Total health system ROI: Unfavourable	High confidence New Zealand-based study Effective and cost-saving intervention (total health system only) 2 year follow-up Unfavourable ROI (public health system and total health system)
J. H. Abbott et al. (2019) New Zealand (NZD 2009)	MOA combined exercise + manual therapy	Intervention cost: $507 Public health system cost: -$162 Private health system cost: $1,291	Intervention cost: $810 Public health system savings $259 Private health system savings -$2,063 Public health system ROI: Unfavourable Total health system ROI: Unfavourable	High confidence New Zealand-based study Effective but not cost-effective from health system perspective Longer than usual follow-up (5 years)

Study	Model of care	Reported cost impacts	Implications (NZ$, 2021)[1]	Key results[1]
				Unfavourable ROI (public health system and total health system)
Bennell et al. (2016) Australia (2012 AUD)	Coping skills (PCST) and exercise combined	Intervention cost Combined: $1,065 PCST: $730 Exercise: $439	Intervention cost Combined: $1,457 PCST: $998 Exercise: $600 Insufficient information for ROI	High confidence in intervention costs Australia-based study Insufficient information for ROI
Fernandes et al. (2017) Denmark (2012 €)	Exercise + education	Intervention cost: €326	Intervention cost: $887	High confidence in intervention cost Intervention was not cost-effective overall
Kloek et al. (2018) Netherlands (2015 €)	Individual exercise w. web app	No cost information	N.a.	Insufficient information for ROI
O'Brien et al. 2018 Australia (AUD 2016)	Telephone-based weight management, education	Intervention cost $622 Public health system cost saving: $41 Medication cost saving: $32	Intervention cost $726 Public health system cost saving: $48 Medication cost saving: $37	Total cost increase due to cost savings not offsetting intervention cost. Insufficient QALY gain for cost-effectiveness.
Pinto et al. (2013) New Zealand (2009 NZD)	MOA exercise only	Intervention cost $503 Public health system cost: +$144 Private health system cost: +$7	Intervention cost $804 Public health system savings: -$230 Private health system savings: -$11 Public health system ROI: Unfavourable Total health system ROI: Unfavourable	High confidence New Zealand-based study Intervention was not cost-effective at 1 year follow-up. Unfavourable ROI (public and total health system) See (J. H. Abbott et al. 2019) for longer term results – increased ROI over longer follow-up.
Pinto et al. (2013) New Zealand (2009 NZD)	MOA manual therapy only	Intervention cost $486 Public health system cost: +$549 Private health system cost: -$374	Intervention cost $777 Public health system savings: -$877 Private health system savings: +$598 Public health system ROI: Unfavourable Total health system ROI: Unfavourable	High confidence in intervention cost and impacts Intervention was not cost-effective at 1 year follow-up. Unfavourable ROI (public and total health system).

Study	Model of care	Reported cost impacts	Implications (NZ$, 2021)[1]	Key results[1]
Pinto et al. (2013) New Zealand (2009 NZD)	MOA combined exercise + manual therapy	Intervention cost $507 Public health system cost: +$549 Private health system cost: -374	Intervention cost $810 Public health system savings: -$877 Private health system savings: -$598 Public health system ROI: Unfavourable Total health system ROI: Unfavourable	High confidence in intervention cost and impacts Intervention was not cost-effective at 1 year follow-up. Unfavourable ROI (public and total health system).
Tan et al. (2016) Netherlands (2011 €)	Exercise therapy in primary care	Public health system savings: €98	Public health system savings: $256	Cost-saving from a public health system perspective. Cost-effective compared with usual care due to savings (no QALY gain) Favourable return on investment.
Wilson et al. (2020) New Zealand (2013 NZD)	Water-based exercise as an adjunctive intervention for persistent symptoms in knee OA where education, land-based exercise and weight loss had already been trialled	Intervention cost $458	Intervention cost $634	High confidence in intervention cost (NZ context) Intervention was cost-effective as an adjunctive intervention in knee OA but results in increased health system costs. Societal costs/savings not reported.

Across the studies, implications for direct impacts of non-surgical, non-pharmacologic models of care on the New Zealand health system (health system savings alone) indicate:

- Intervention costs are likely to be between $550 and $3,000, depending on the intervention design (the New Zealand Joint clinic had the lowest intervention cost, and an Australian combined exercise and education intervention had the highest intervention cost).
- Public health system savings are most likely to occur when the patient has knee OA, the intervention includes exercise (ESCAPE and MOA), and the follow-up time is longer. The MOA trial demonstrated health system net costs at one year but health system net savings at the two- and five-year follow-ups.
- Public health system savings range from -$2,616 to $2,737, with the lowest figure associated with a manual therapy only intervention and the highest with the ESCAPE-knee pain exercise intervention. Exercise-only interventions are associated with a range of public health system savings from -$230 to $2,737.
- The public health system return on investment for exercise, manual therapy, and combined interventions is generally unfavourable in the short term due to public health system savings alone being insufficient to offset the intervention cost: The MOA

trial exercise only intervention had a small favourable ROI from a public health system perspective ($0.11 in net benefits per $1 invested) at 2 year follow-up.

- Total health system savings (including public and private health services) range from -$2,551 to $1,776, with large negative values associated with combination exercise and manual therapy interventions due to a shifting of costs from public health system to private health system. Exercise only interventions result in total health system savings between -$11 and $1,776, suggesting these are more likely to result in total system savings.
- From a total health system perspective, the return on investment for exercise and exercise-based interventions is mixed. However, the ESCAPE-knee pain exercise intervention (followed up at 30 months) and the MOA exercise only intervention (followed up at 2 years) had favourable ROI of $1.36 and $2.86, respectively, per $1 invested, demonstrating that in New Zealand and countries with similar systems, these models of care do offer a favourable ROI when at least 2 years of follow-up are included.

4.3 Other financial cost impacts

Outside of health system costs, some studies identified impacts on patients, their families and other supports, and productivity impacts. Factoring this information into return on investment provides for a societal financial return on investment, or ROI without the value of QALYs. Table 7 below describes the information that was derived from studies to inform this dimension.

Table 7 Implications of other financial cost impacts

Based on included studies

Study	Model of care	Reported cost impacts	Implications (NZ$, 2021)	Key features
J. H. Abbott et al. (2019) New Zealand (NZD 2009)	MOA exercise only 2 yr follow-up	Patient, family and friends' cost: -$859 Productivity cost: -$1,736	Patient, family and friends' savings $1,373 Productivity savings: $1,736 Societal ROI: $1:$6.73 (w/o QALYs)	High confidence New Zealand-based study Effective and cost saving intervention (public health system, total health system and societal) 2 year follow-up Highly favourable ROI
J. H. Abbott et al. (2019) New Zealand (NZD 2009)	MOA manual therapy only 2 yr follow-up	Patient, family and friends' cost -$671 Productivity cost: -$2,524	Patient, family and friends' savings $1,072 Productivity savings: $4,034 Societal ROI: $1:$5.49 (w/o QALYs)	High confidence New Zealand-based study Effective and cost saving intervention (total health system and societal only) 2 year follow-up Highly favourable ROI (societal)

Study	Model of care	Reported cost impacts	Implications (NZ$, 2021)	Key features
J. H. Abbott et al. (2019) New Zealand (NZD 2009)	MOA combined exercise + manual therapy 2 yr follow-up	Patient, family and friends' cost -$548 Productivity cost: -$878	Patient, family and friends' savings $876 Productivity savings: $1,403 Societal ROI: $1:$0.59 (w/o QALYs)	High confidence New Zealand-based study Effective and cost-effective intervention (societal only) 2 year follow-up Favourable ROI
Pinto et al. (2013) New Zealand (2009 NZD)	MOA exercise only 1 yr follow-up	Patient, family, friends cost: +$160 Productivity cost: -$263	Patient, family, friends' savings: -$256 Productivity savings: +$420 Societal ROI: Unfavourable (w/o QALYs)	High confidence New Zealand-based study Intervention was not cost-effective at 1 year follow-up. Unfavourable ROI (societal). See J. H. Abbott et al. (2019) for longer term results – increased ROI over longer follow-up.
Pinto et al. (2013) New Zealand (2009 NZD)	MOA manual therapy only 1 yr follow-up	Patient, family, friends cost: -$5 Productivity cost: -$810	Patient, family, friends' savings: +$8 Productivity savings: +$1,295 Societal ROI: $1:$1.32 (w/o QALYs)	High confidence in intervention cost and impacts Intervention was not cost-effective at 1 year follow-up. Favourable ROI (societal).
Pinto et al. (2013) New Zealand (2009 NZD)	MOA combined exercise + manual therapy 1 yr follow-up	Patient, family, friends: +$160 Productivity cost: -$644	Patient, family, friends' savings: -$256 Productivity savings: $1,030 Societal ROI: Favourable (w/o QALYs)	High confidence in intervention cost and impacts Intervention was not cost-effective at 1 year follow-up. Favourable ROI (societal).
Tan et al. (2016) Netherlands (2011 €)	Exercise therapy in primary care	Productivity savings: €508	Productivity savings: $1,327 Societal ROI: Favourable (w/o QALYs). Value can't be calculated due to reported cost savings not being quantified.	Cost-saving from a public health system and societal perspective. Cost-effective compared with usual care due to savings (no QALY gain) Favourable return on investment (public health system and societal)

The inclusion of costs to patients (including out-of-pocket costs and productivity costs) and their family and friends has a significant impact on return on investment for OA interventions:

- Exercise interventions and manual therapy interventions have a favourable return on investment within 12 months).
- Exercise interventions and manual therapy interventions have highly favourable returns on investment by 2 years.
- Combined exercise and manual therapy interventions have a favourable return on investment within 2 years.
- One exercise intervention (the MOA exercise only intervention) achieved a societal return on investment of $6.73 per dollar invested (not including the value of additional

QALYs) at two years after having an unfavourable societal return on investment at one year of follow up.

4.4 Implications of quality of life impacts

In Table 8 below, QALYs gained are valued at the lower Treasury CBAx value of $36,363 to calculate a societal return on investment, including a conservative valuation of quality of life impacts.

Table 8 Implications of QALY impacts

Based on included studies

Study	Model of care	Reported cost impacts	Implications (NZ$, 2021)	Key features
J. H. Abbott et al. (2019) New Zealand (NZD 2009)	MOA exercise only	QALY gain: 0.15	QALY value: $5,468 Societal ROI: $1:$13.64 (w QALYs)	High confidence New Zealand-based study Effective and cost saving intervention (public health system, total health system and societal) 2 year follow-up Highly favourable ROI – all perspectives
J. H. Abbott et al. (2019) New Zealand (NZD 2009)	MOA manual therapy only	QALY gain: 0.08	QALY value: $2,917 Societal ROI: $1:$8.81 (w QALYs)	High confidence New Zealand-based study Effective and cost saving intervention (total health system and societal only) 2 year follow-up Highly favourable ROI – societal only
J. H. Abbott et al. (2019) New Zealand (NZD 2009)	MOA combined exercise + manual therapy	QALY gain: 0.07	QALY value: $2,551 Societal ROI: $1:$3.37 (w QALYs)	High confidence New Zealand-based study Effective and cost-effective intervention (societal only) 2 year follow-up Highly favourable ROI – societal only
Fernandes et al. (2017) Denmark (2012 €)	Exercise + education	QALY gain: 0.05	QALY value: $1,818 Societal ROI: $1:$1.82 (w QALYs) assuming no additional costs.	High confidence in intervention cost and QALY value Intervention was not cost-effective overall Societal ROI favourable conditional on no increased health system or productivity costs.
Kloek et al. (2018) Netherlands (2015 €)	Individual exercise w. web app	QALY gain: 0.01	QALY value: $364 Insufficient information for ROI	Medium confidence Value of QALY impact only Insufficient information for ROI

Study	Model of care	Reported cost impacts	Implications (NZ$, 2021)	Key features
Pinto et al. (2013) New Zealand (2009 NZD)	MOA exercise only	QALY gain: +0.04	QALY value: $1,454 Societal ROI: $1:$1.51 (w QALYs)	High confidence New Zealand-based study Intervention was not cost-effective at 1 year follow-up. Negative ROI public health system and private health system. Favourable ROI societal. See J. H. Abbott et al. (2019) for longer term results – increased ROI over longer follow-up.
Pinto et al. (2013) New Zealand (2009 NZD)	MOA manual therapy only	QALY gain: +0.009	QALY value: $327 Societal ROI $1:$1.69 (w QALYs)	High confidence in intervention cost and impacts Intervention was not cost-effective at 1 year follow-up. Favourable ROI public health system and private health system. Favourable ROI societal.
Pinto et al. (2013) New Zealand (2009 NZD)	MOA combined exercise + manual therapy	QALY gain: +0.016	QALY value: $536 Societal ROI: Unfavourable (w QALYs)	High confidence in intervention cost and impacts Intervention was not cost-effective at 1 year follow-up. Unfavourable ROI due to QALY gains being insufficient to justify costs.

These results indicate that when quality of life improvement is taken into account, interventions are more likely to offer a favourable or very favourable return on investment from a societal perspective. The results also suggest that short-term return on investment is still susceptible to being dominated by costs, such as in the combined exercise and manual therapy intervention, due to relatively small quality of life gains relative to usual care. However, even a more costly combined intervention involving both exercise and manual therapy delivers a highly favourable return on investment over a two year or longer timeframe.

5 Conclusion and recommendations

The evidence on non-surgical, non-pharmacologic models of care in OA is growing, with a small and promising sub-group of studies providing at least some health economic information. While many studies do not provide information that is amenable to identifying the potential for return on investment, or in some cases, even cost-utility:

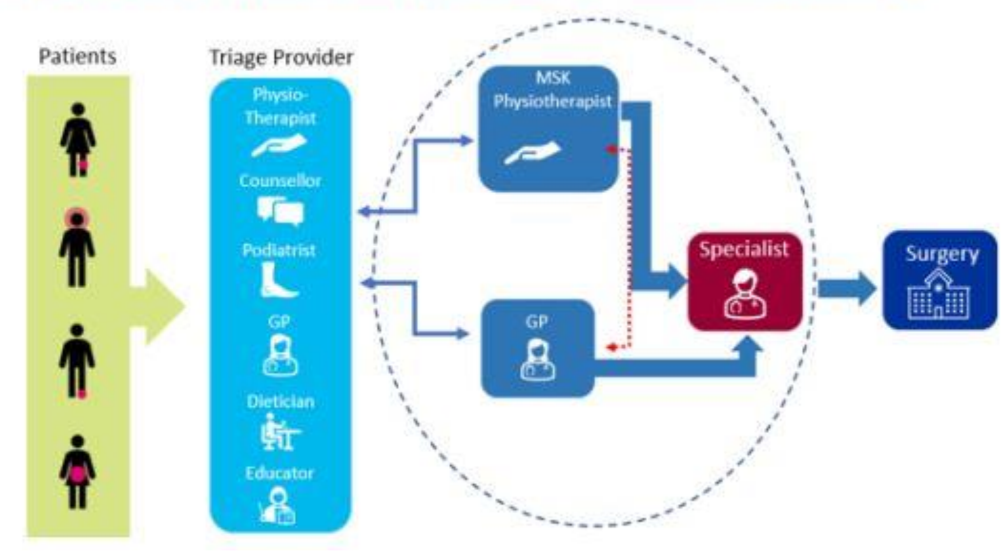
- A wide range of studies, including but not limited to those reviewed for this report, describe improvements in clinical outcomes related to pain, function and psychological aspects. The consistency of positive clinical outcomes warrants more attention on the economic aspects of models of care.
- The small number of studies that do provide information amenable to economic analysis and from which a return on investment can be calculated indicate that it is possible to achieve a favourable return on investment from a societal perspective

within a short time and that longer term impacts of non-surgical, non-pharmacologic models of care can create a favourable public health system return on investment as well.

- From the 13 studies reviewed, exercise-based models of care appear to be the most likely to provide a favourable return on investment in the short term from a public health system perspective.
- Non-surgical, non-pharmacologic interventions generally require a longer time horizon to demonstrate value, but evidence indicates that over the longer time horizon, the value of well-designed interventions exceeds the value of usual care.
- Highly successful models identified in this review are the MOA trial which provides compelling evidence of cost-effectiveness and return on investment in a New Zealand context with up to five years of follow-up, and the ESCAPE-knee pain exercise programme, which has been associated with highly favourable results in the UK.
- Successful models of care for osteoarthritis reduce GP visits, specialist visits, medication costs and allow patients to delay or avoid costly surgery while improving quality of life and reducing productivity and informal care costs.
- It is not generally cost-effective at the Treasury value of a QALY to add manual therapy or significant education components to exercise programmes, although from a societal perspective, these combined models of care can offer a favourable return on investment.

Successful models of care for OA offer a solution that is not only a cost-effective way of delivering improved outcomes but takes pressure off parts of the health system that are currently under heavy demand and generating unmet need. Non-surgical models of care for osteoarthritis – like other musculoskeletal conditions – could include direct access to transdisciplinary allied health teams with referrals back to GPs or on to specialists as needed, reducing pressure on GPs, specialists, and operating theatres (see Figure 13 below).

Figure 13 The right model of care can reduce pressure on GPs and hospitals



Source: NZIER (2020) adapted by AHANZ

In the April 2021 Health Reform White Paper, the themes of sustainability and person and whānau-centred care are of particular relevance and indicate value for non-surgical, non-pharmacologic models of care that the studies reviewed do not fully illustrate. Successful non-surgical, non-pharmacologic models of care can:

- “prevent and reduce health need instead of just addressing illness”
- “promote efficient, high quality care”
- “empower everyone to manage their own health and wellbeing, giving people, their carers and whānau meaningful control”
- support a system where “everyone can access a wider range of support to stay well in the community, with more services designed around people’s needs and which better support self-care”.

  (Department of Prime Minister and Cabinet 2021, 3)

In light of these findings, we recommend:

- Improved access to cost-effective interventions including exercise programmes (with information and support for self-management strategies including weight management where overweight or obesity is a factor) in the community for people with knee or hip OA who are experiencing functional limitations and/or pain and are otherwise likely to be referred for surgery.
- Further investigation into other interventions which may be effective and cost-effective for patients who may choose not to engage with or adhere to exercise-based programmes, including weight management, education and manual therapy, and

weight management as a preventive intervention in people who are overweight or obese.

- Implementation of a triage provider model to improve access to OA care, reduce pressure on the health system, and support a more patient-centred approach to OA.

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Appendix A Overview of studies

A.1 Education and self-management studies

Only one study evaluating an intervention involving education and self-management (O'Brien et al. 2018) provided information that could inform a health economic assessment.

Table 9 Education and self-management

	Intervention	Comparator	Design	Population characteristics	Delivery	Follow-up
O'Brien et al. (2018) Australia (Knee)	Telephone-based weight management, education, phone coaching	'Usual care'	Pragmatic RCT=120	On wait list for orthopaedic consult for knee OA, pain>3 months, age 18+, overweight or obese	brief advice +education about weight loss and physical activity + info about the NSW Get Healthy Information and Coaching Service (GHS)	6 months

A.2 Education and self-management results

The education and self-management intervention was unable to demonstrate any improvement in QALYs and the cost was significantly higher than the comparator. The results, indicate that this intervention is unlikely to be cost-effective and is likely to be associated with a negative return on investment. This result is based on only one study which was as much about the mechanism of delivery than the content delivered, so further investigation of education and self-management programmes is warranted.

Table 10 Results summary table

	Health system	Other costs	Societal	Results	Conclusion	Confidence
O'Brien et al. (2018) Australia (AUD2016)	Intervention cost: $622 Other health system costs: $3,346 v $3487(control) Medication: 107 v 139	Absenteeism higher than in control group: $310 v 193.	n.a.	No significant difference in QALYs Higher cost: $4387 v 3819 $387,820/QALY (health system perspective) $581,828/QALY (societal perspective)	Higher cost (health system and societal), no gain in QALYs. Not cost-effective	High

A.3 Exercise (with or without manual therapy and/or education) studies

Table 11 Knee OA only

Author, year, context	Intervention	Comparator	Design	Population characteristic	Delivery	Follow-up
Bennell et al. (2016) Australia	12-week physical therapist–delivered treatment combining PCST (pain education, coping skills) and exercise	Exercise only or PCST only	RCT=222	Age >=50 American College of Rheumatology criteria (pain on most days in the past month and radiographic changes)	Physiotherapist 10 individual sessions over 12 weeks, 45 minutes each for PCST, 25 for exercise, 70 minutes combined + daily home-based practice, phone follow-ups re progress and adherence at 22, 38 and 46 weeks	1 year
Bove et al. (2018) US	Individual exercise with booster sessions with and w/o manual therapy	Physio supervised w booster vs independent exercise Physio supervised w booster vs w/o booster Physio supervised w booster vs w manual therapy	RCT=300	ACR criteria	Physiotherapist	2yrs observed 5yr model
Hurley et al. (2012) UK	ESCAPE knee pain: Exercise-based rehabilitation programme	Usual primary care	Pragmatic, cluster randomised RCT= 418	Chronic knee pain from primary care	Supervised by physiotherapist 12 sessions twice weekly x 6 weeks with coping strategies + home exercise	30 months
Kigozi et al. (2018) UK	Individual exercise programme and group exercise	Usual rehab care by physiotherapist	RCT=514	Meeting NICE criteria, age>=45	Physiotherapist	18 months

Author, year, context	Intervention	Comparator	Design	Population characteristic	Delivery	Follow-up
Mahendira et al. (2020) Canada	Comprehensive multi-disciplinary non-surgical intervention including standardised exercise programme with pharmacologic interventions	Surgery	Prospective =131	radiographic criteria for moderate to severe OAK, referred to orthopaedic service for arthroplasty Average BMI=35	Multi-disciplinary team: rheumatologists, physiotherapists, nurses + occupational therapists	2 years
York Health Economic Consortium (2017) UK	ESCAPE Knee pain: Exercise-based rehabilitation programme				Supervised by physiotherapist 12 sessions twice weekly x 6 weeks with coping strategies + home exercise	
van de Graaf et al. (2020) Netherlands	Physiotherapy + exercise programme	Arthroscopic partial meniscectomy (APM)	Multi-centre RCT=321	Age 45-70 with non-obstructive meniscal tear	PT protocol developed by knee-specialist physiotherapist 16 sessions x 30 minutes per week for 8 weeks + home exercise programme	2 years
Wilson et al. 2020) New Zealand	Water-based exercise and other adjunctive interventions	"core treatments" of patient education, land-based exercise therapy, weight loss, followed by TKR for patients whose symptoms persist	Computer simulation based on previously published evidence of effectiveness combined using Cochrane collaboration guidelines for meta-analysis	Age 35-99 with knee pain and radiographic knee OA whose symptoms persist after receiving "core treatments"	As per underlying studies	Lifetime (simulated)

Table 12 Hip OA only

Author, year, context	Intervention	Comparator	Design	Population characteristic	Delivery	Follow-up
Tan et al. (2016) Netherlands	Exercise therapy –standardised exercise programme	Usual GP care (incl education + counselling) Baseline 3/10 patients visited	RCT=203	Age>=45, symptomatic, no hip surgery, no disabling comorbidity	Physiotherapist 12 sessions in 3 months + booster sessions	1 year

Author, year, context	Intervention	Comparator	Design	Population characteristic	Delivery	Follow-up
		GP, 1/10 visited physio			at 5, 7 and 9 months	
Svege et al. (2015) Norway	Exercise therapy	Usual GP care with 3 group sessions of patient education + 2 month follow up	RCT=109	Age 40-80 Hip pain at least 3 months, minimum clinical criteria applied Excl. knee OA	Strengthening, flexibility and functional exercises 2-3 x per week for 12 weeks Physical therapist supervised at least 1 per week	6 years

Table 13 Hip or knee OA

Author, year, context	Intervention	Comparator	Design	Population characteristic	Delivery	Follow-up
J. Haxby Abbott et al. (2019) New Zealand	Joint clinic to manage unmet need	Usual care: GP referral to orthopaedic surgery with high rate of declined referrals	Longitu-dinal pro-gramme evaluation= 637 patients over 2 years	ACR criteria	Physiothera pist	2 years
J. Haxby Abbott, Wilson, and Pinto (2019) New Zealand	MOA. Individual exercise programme alone or with manual therapy	Usual physician care	RCT=206	ACR criteria	Physio-therapist	5 years obs. Lifetime model (3.5% discountin g)
Fernandes et al. (2017) Denmark	Combined group neuromuscular exercise + education over 8 weeks	Pre-op education	RCT=165	Waiting for hip/knee surgery, symptomatic age 18+	Supervised by physio-therapist	61 weeks
Kloek et al. (2018) Netherlands	Individual exercise w. web app	Usual physiotherapist rehab care	RCT=207	ACR criteria, age 40-80, inactive	Physio-therapist	1 year
D. Pinto et al. (2013) New Zealand	Individual exercise alone or with manual therapy	Usual physician care (GP and other)	RCT=206	ACR criteria	Manual therapy focused on improving joint Mobility. Exercise therapy focused on increasing strength, neuro-muscular control and flexibility of	I year

Author, year, context	Intervention	Comparator	Design	Population characteristic	Delivery	Follow-up
					the muscles of the lower extremities.	

A.4 Exercise results

Table 14 Knee OA only

Author, year, context	Health system costs	Other costs	Overall results	Conclusion	Transfer confidence
Bennell et al. (2016) Australia (AUD 2012)	Intervention costs AU$439 for exercise, $730 for PCST, $1,065 for combo	Not included	Small difference in QALYs +0.03 Costs not offset	Significant improvements in clinical outcomes but cost-utility from combined treatment does not indicate it should be favoured over either treatment alone.	Medium (similar system)
Bove et al. (2018) US (2011 USD)	1 yr programme cost	Included. Not reported	Physio booster and manual therapy adds 0.062 QALYs to independent exercise Cost-saving (societal?)	Not cost-effective (societal) (reported as cost-effective with 2011 USD50K and 100K thresholds)	Low (different system, inappropriate comparator, old costs)
Hurley et al. (2012) UK (£ 2003/ 2004)	Intervention cost £224 Lower community-based health care costs: -£47 medication: -£16 total health and social care: -£1,177		Group exercise just as effective as individual but less costly	High probability of being cost-effective based on willingness to pay for WOMAC improvement	High
Kigozi et al. (2018) UK (£ 2012-13)	Individual exercise programme: increased cost Targeted exercise adherence: increased cost No significant difference in primary and	Included, not reported.	Individual exercise programme: -0.015 QALYs Targeted exercise adherence: -0.03 QALYs	Dominated by usual care, higher health system costs, no increase in QALYs	Low (similar system, inappropriate comparator – physio rehab, old costs)

Author, year, context	Health system costs	Other costs	Overall results	Conclusion	Transfer confidence
	secondary care.				
Mahendira et al. (2020) Canada (CDN2018)	Lower intervention cost $925 v $10,477 for surgery No other costs included	No societal costs	Cost-saving (only 5% of patients went on to have surgery) but only intervention and surgery costs included – no total resource utilisation	Cost-effective	Low (very limited range of costs included)
York Health Economic Consortium (2017) UK Knee	ESCAPE knee pain exercise programme	Intervention costs offset by 4+ times higher savings in health system costs and societal costs	Cost-saving from health system and societal perspective	No QALY impacts reported but older study (Hurley et al) indicates no significant change (see Table in section 14)	Cost-saving Health system ROI =£5.20 per £1 invested Societal ROI=£5.20 per £1
van de Graaf et al. (2020) Netherlands	Intervention cost Surgery cost Primary and secondary health service use Medication	Paid home care Informal care Absenteeism Presenteeism Unpaid productivity loss	At 24 months, mean intervention and total societal costs lower in PT group. Costs of paid help, absenteeism, informal care and unpaid productivity lower in the PT group than in the APM group	Intervention is cost saving Probability of non-inferiority in terms of QALYs = 0.89 Potential loss of QALYs associated with savings of €61 584 per QALY lost	Medium
Wilson et al. (2020) New Zealand ($NZ 2013)	Intervention costs Other treatment costs	No societal costs	Water-based exercise for patients whose symptoms persist after "core treatments" of education, land-based exercise, and weight loss if overweight or obese, is associated with $458 in additional health system costs and provides 0.023 incremental utility gain.	Water-based exercise for patients whose symptoms persist after "core treatments" of education, land-based exercise, and weight loss if overweight or obese, offers a cost-effective adjunctive treatment option with QALYs at a cost within GDP per capita	High New Zealand costs High quality intervention effectiveness data (meta-analysis)

Table 15 Hip OA only

Author, year, context	Health system costs	Other costs	Overall results	Conclusion	Transfer confidence
Tan et al. (2016) Netherlands (€ 2011)	All visits (GP, specialist, allied health), hospitalisation, rehab, nursing home, medical imaging, laboratory services, medications, appliances, home care. Lower direct medical costs (€1233 vs €1331) Hip surgeries account for 25% of direct costs. Negligible use of other allied health. Medication cost (€16.4 v €35.2)	Productivity improvements v control: From €1910 to €1401 (total prod.) €399 to €120 (unpaid work) €1396 to €1215 (presenteeism) €791 to €120 (absenteeism)	Major cost for intervention group is the intervention. Hospital days 0.5 to 0.3. GP visits 0.8 to 0.5. Company physician visits[4] (0.3 to 0)	Exercise therapy probably cost saving from a health system and societal perspective No QALY gain Cost-effective due to savings relative to usual care and no loss of QALYs	Medium
Svege et al. (2015) Norway (no costs reported)	THR reduced 30% in exercise group (22 from 31 in control group) Median time to THR extended from 3.5 to 5.4 years	Not reported	Improvements in clinical outcomes and cost savings from avoided/delayed THR (not quantified)	Confirmed previous studies findings of avoided/ delayed THR from exercise therapy	High[5]

Table 16 Hip or knee OA

Author, year, context	Health system costs	Societal costs	QALYs, ICER Results	Conclusion[6]	Transfer Confidence
J. Haxby Abbott et al. (2019) New Zealand (NZD 2009)	Intervention: $550 per patient year 1, $384 per patient year 2 reduction in FSAs: 93%. reduction in referrals returned to GP	Not reported		A physiotherapist-led clinic in a secondary care setting is feasible, effective in reducing unmet need, and acceptable to stakeholders	High

4 Visits to company physician not appropriate for direct application to New Zealand context and unlikely to be appropriate for combining with GP visits since company physicians in the Netherlands are likely to have no co-payment.

5 This study was given a high confidence rating for transferability of impact as the reported impact does not rely on costing and is likely to be achievable in the New Zealand context due to the high rate of THR in people with hip OA.

6 Cost-effectiveness judged at NZ Treasury value of $32,000 per QALY gained.

Author, year, context	Health system costs	Societal costs	QALYs, ICER Results	Conclusion[6]	Transfer Confidence
J. H. Abbott et al. (2019) New Zealand (2009 NZD) MOA Exercise + manual therapy	Total costs only. Savings v usual care: $7,410 - $7,248 (public) Costs: $1,863 - $3,154 (private) Total cost: $9,273 - $10,908	Savings to patient, family and friends: $1,477-$929 Total societal cost v usual care: $15,370 - $15,580	+0.07 QALYs ICER: $20,832 per QALY gained (societal) $35,566 per QALY gained (health system)	Cost-effective from a health system and societal perspective	High
(J. H. Abbott et al. 2019) New Zealand (2009 NZD) MOA Exercise only	Total costs only. Savings v usual care: $7,410 - $6,857 (public) $1,863 - $984 (private) Total savings: $9,273 - $8,338	Savings to patient, family and friends: $1,477-$618 Total societal savings: $15,370-$11,840	+0.15 QALYs ICER: -3,657 per QALY gained (health system) -16,616 per QALY gained (societal)	Cost-saving (societal and health system) Dominates usual care Results confirmed in 5 year results and lifetime modelling results (J. Haxby Abbott, Wilson, and Pinto 2019)	High
Fernandes et al. (2017) Denmark (2012 EUR)	Intervention cost 326 euros per patient = $887 (NZD, 2021) GP visits 19.5 to 18.2. Specialist visits 1 to 0.9. Other allied 0.4 to 0. ED visits 9 to 8.6		0.05 QALYs (valued at $1,613, 2021 NZD) No difference in total cost. €20,000 per QALY gained (2012) = $57,003, (NZD 2021)	Potentially cost-effective from a health system perspective.	Medium
Kloek et al. (2018) Netherlands (2015 EUR)	Reduced cost substituting app for physio		0.01 QALYs	Minimal QALY gain overall – highly variable results. Reduced cost. Potential where preference indicated.	Low (different system, inappropriate comparator)
D. Pinto et al. (2013) New Zealand (2009 NZD)[7] MOA	Intervention costs not offset. 80% reduction in rheumatology visits (mean 0.1 to 0.02 exercise, 0.0 combined), A&E (0.08 to 0.02, 0.00), GP (1.75 to 1.53, 1.74), Practice nurse (0.12 to 0.06, 0.12) Increase in	Exercise: cost-saving	Exercise only most cost-effective 0.035 QALYs $26,400/QALY gained ($42,194 in 2021)	Exercise cost-effective from health system and societal perspective – more cost-effective than comparator – at the VoSL-based QALY value. Adding manual therapy reduces cost-effectiveness.	High

[7] Older values, older NZ system. Medium confidence.

Author, year, context	Health system costs	Societal costs	QALYs, ICER Results	Conclusion[6]	Transfer Confidence
	radiology (mean 0.35 to 0.43, 0.5 combined,				

A.5 Diet and exercise studies

Table 17 Hip or knee OA

Author, year, context	Intervention	Comparator	Design	Population characteristic	Delivery	Follow-up
Losina et al. (2019) US	Intensive diet and exercise programme	Usual care (pharmacologic NSAIDs regimen leading to TKA)	Modelling study (OAPol)	Mean age 66 Mean BMI 33.6	2 year programme	Lifetime (modelled)
Smith et al. (2020) US	Intensive diet and exercise programme alongside usual care for overweight and obese patients with knee OA	Usual care (pharmacological and surgical interventions)	Modelling study (Osteoarthritis Policy (OAPol) Model)	Overweight and obese (BMI>30), aged 55-84, with knee OA and no prior TKR	Meal replacements and nutrition classes (weekly or bi-weekly, first year only) + non-specialist exercise classes (3h/wk)	3 years modelled

A.6 Diet and exercise results

Table 18 Hip or knee OA

Author, year, context	Health system costs	Other costs	Overall results	Conclusion	Transfer confidence
Losina et al. (2019) US (2016 USD)	Increased health system cost $1,845	Increased societal cost $1,624	ICER of $34,100/QALY (health system) $30,000/QALY (societal) Mean 10.6kg weight loss 51% pain reduction 0.054 QALYs gained	Cost-effective from a societal perspective at the VoSL-based QALY value (almost cost-effective from a health system perspective). (NZ $50,800 societal NZ$57,743 health system)	Low (dissimilar system)

Author, year, context	Health system costs	Other costs	Overall results	Conclusion	Transfer confidence
Smith et al. (2020) US (2016 USD)	Increased health insurer cost by $2,900 6% to 7% of programme costs offset by reduction in TKR over 3 years Additional 6% to 7% of programme costs offset by reduction in other knee OA treatments.	No other costs reported	A diet and exercise programme included in a medical insurance would increase the per member per month cost by $0.84 (based on a Medicare plan)	Inclusion of a diet and exercise programme in a Medicare-type insurance plan would be affordable at a cost very similar to lung cancer screening for high risk patients	Low (dissimilar system)

A.7 Education and exercise studies

Table 19 Hip or knee OA

Author year	Intervention	Comparator	Design	Population characteristic	Delivery	Follow-up
Skou and Roos (2017) Denmark	GLA:D (2 day course for physiotherapists 8 weeks, incl, 3 education sessions (incl 1 by 'expert patient') over 3 weeks & supervised neuromuscular exercise for patients)	Baseline	Registry based study/ evaluation	knee and/or hip joint problems resulting in health care demand	Delivered by trained physiotherapist in clinical practice	12 months
Roos et al. (2021) Denmark, Canada, Australia	GLA:D (2 day course for physiotherapists 8 weeks, incl, 3 education sessions (incl 1 by 'expert patient') over 3 weeks & supervised neuromuscular exercise for patients)	Baseline	Longitudinal registry-based	knee and/or hip joint problems resulting in health care demand	Delivered by trained physiotherapist in clinical practice. Was introduced in Denmark in 2013, in Canada in 2015, and in Australia in 2016.	3 months
Cuperus et al. (2016) Netherlands	Telephone-based lifestyle advice and self-management with individually		Pragmatic RCT=120	On wait list for orthopaedic consult for knee OA, pain>3 months, age	brief advice +education about weight loss and physical activity + info about the NSW	6 months

Author year	Intervention	Comparator	Design	Population characteristic	Delivery	Follow-up
	tailored exercise programme Face to face lifestyle advice and self-management with individually tailored exercise programme			18+, overweight or obese	Get Healthy Information and Coaching Service (GHS)	

Table 20 Education and exercise results

Author, year, context	Health system costs	Other costs	Overall results	Conclusion	Transfer confidence
Skou and Roos (2017) Denmark	Risk reduction 19.3% for taking pain killers at 3 months	Significantly fewer patients on sick leave at 12 months – risk reduction=9.4%	Odds of being more physically active at 3 months=1.18, at 12 months=1.10 Improved QoL	Good clinical outcomes. Indication of potential societal cost savings. Lack of quantitative health economic data.	Medium
Roos et al. (2021) Denmark, Canada, Australia	1/3 stop use of paracetamol/non-steroidal anti-inflammatory drugs and opioids	Reduced sick leave 1/3 stop paracetamol/non-steroidal anti-inflammatory drugs and opioids, Pain reduced 25% Improved function, QoL and physical activity		Good clinical outcomes. Indication of potential societal cost savings. Lack of quantitative health economic data.	Medium
Cuperus et al. (2016) Netherlands	Intervention costs of face-to-face treatment estimated at €387 and telephone-based treatment were €252, respectively, offset by total medical cost difference: €3042 for face-to-face and €3443 for telephone.	Societal costs of face-to-face lower at €10,324 v €11,023 Patient time and travel costs accounted for. Productivity costs (absenteeism only). Domestic help.	Similar QALYs (0.75 v 0.74 favouring face to face with EQ-5D, 0.69 v 0.68 favouring face to face with SF-6D) Increased intervention costs offset by lower medical costs and lower societal costs indicating cost-effectiveness of face-to-face from health system and societal perspective.	Face-to-face intervention delivery is more cost-effective.	Medium