National Institute for Health and Care Excellence

Final

Joint replacement (primary): hip, knee and shoulder

[T] Evidence review for long-term follow-up and monitoring

NICE guideline NG157

Intervention evidence review underpinning recommendation 1.11.1 and the research recommendation in the NICE guideline

June 2020

Final

This evidence review was developed by the National Guideline Centre, hosted by the Royal College of Physicians

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1 Long-term monitoring

1.1 Review questions:

- In adults having primary elective joint replacement, what would be the optimal timing of follow-up or surveillance appointments?
- In adults having primary elective joint replacement, who should carry out follow-up or surveillance appointments?
- In adults having primary elective joint replacement, should x-rays be undertaken for all follow-up or surveillance appointments?

1.2 Introduction

Primary elective hip, knee and shoulder replacement surgery aims to reduce joint pain and increase function in people with joint degeneration, but short-term complications from the operation or longer term from the failure of the joint replacement, can cause significantly poor outcomes.

There is uncertainty whether healthcare professionals should routinely monitor people for complications after their operation and at what intervals. One approach currently used is, if a problem arises, most commonly worsening pain, to advise people who have had a hip, knee or shoulder replacement to contact their General Practitioner (GP) or hospital orthopaedic team. This leads to a series of investigations to determine if, for example, physiotherapy or further surgery is required. Another approach is to monitor patients with x-rays and questionnaires at regular intervals, such as one, three, five and 10 years after joint replacement. There are potential clinical benefits in regular monitoring to detect adverse changes including asymptomatic complications, but the total cost to the NHS, given the number of joint replacements performed in the UK, is significant. The cost-benefits of regular monitoring are therefore uncertain.

There is variability in UK provision in terms of long-term follow-up and monitoring for people after hip, knee and shoulder replacement. Some are discharged six weeks after the operation and advised to contact their GP if they experience problems; the GP can re-refer to an orthopaedic team. Others have routine follow-up appointments at six to 12 months with a member of the orthopaedic team and are then discharged. Yet others have annual or biannual questionnaire assessments to monitor pain and function and are only contacted by the orthopaedic team if their scores suggest they have significantly deteriorated.

There have been developments in digital technology where individuals can be remotely monitored using tele- or video-conferencing facilities. This has allowed follow-up appointments without the need for person to attend the hospital or clinic environment.

Given this variability in current practice and the changing technology, this review seeks to explore a number of questions around long-term follow-up and monitoring of people after hip, knee and shoulder replacement. It seeks to determine when people should be followed-up after their joint replacement surgery, who should carry out this follow-up and whether x-rays should be undertaken at all follow-up appointments.

1.3 PICO table

For full details, see the review protocol in Appendix A:

Table 1: PICO characteristics of review question

Population	Adults who have undergone primary hip, knee or shoulder joint replacement.
Interventions	Follow up/surveillance strategy Interventions separated by: • Timing of appointments points starting from initial follow-up /surveillance appointment • The healthcare professionals carrying out the follow-up /surveillance appointments, for example, a member of the orthopaedic team, GP or physiotherapist. • Whether routine x-rays are utilised for each follow-up /surveillance monitoring appointment.
Comparison	Comparison of interventions
Outcomes	Critical • Emergency reoperation (dichotomous) • Mortality: life expectancy (time to event) • Quality of life at 2 years after surgery, at the longest time point (at least 4 years after surgery) (continuous): for example EQ-5D, EQ-VAS. • Patient Reported Outcome Measures (PROMs) at 2 years after surgery, at the longest time point (at least 4 years after surgery; continuous) • Reoperation (including revision) at 2 years after surgery, at the longest time point (at least 4 years after surgery; dichotomous) To be extracted when not included within a PROM: • Function at 2 years after surgery, at the longest time point (at least 4 years after surgery; continuous) • Pain at 2 years after surgery, at the longest time point (at least 4 years after surgery; continuous)
Study design	Randomised controlled trials If no well-conducted RCTs are available, then observational studies with multivariate analysis will be investigated.

1.4 Clinical evidence

1.4.1 Included studies

A search was conducted for studies comparing long-term follow-up strategies for people who have undergone primary hip, knee or shoulder joint replacement surgery.

No relevant clinical studies investigating follow-up programs were identified. See also the study selection flow chart in Appendix C:

1.4.2 Excluded studies

See the excluded studies list in Appendix I:

1.4.3 Summary of clinical studies included in the evidence review

No clinical evidence was identified.

1.4.4 Quality assessment of clinical studies included in the evidence review

No clinical evidence was identified.

1.5 Economic evidence

1.5.1 Included studies

One health economic study was identified with the relevant comparison and has been included in this review [50]. The study is summarised in the health economic evidence profile below (Table 2) and the health economic evidence table in Appendix H:

1.5.2 Excluded studies

Two health economic studies that were relevant to this question were excluded due to assessment of methodological limitations.

See also the health economic study selection flow chart in Appendix G: and excluded studies in Appendix I:

1.5.3 Summary of studies included in the economic evidence review

Table 2: Health economic evidence profile: New BOA follow up guidelines versus the old BOA follow up guidelines

Study	Applicability	Limitations	Other comments	Incremental cost	Incremental effects	Cost effectiveness	Uncertainty
Roberts 2016[50][UK]	Partially applicable[(a)]	Potentially serious limitations[(b)]	Population: people with total hip replacement on the NJR in 2012 Design: cohort model comparing follow up strategies Strategies: (1) Old BOA follow up guidelines[(c)] (2) New BOA follow up guidelines[(d)]	(2-1): Follow up under the new BOA guidelines is more expensive by £350 per patient.	Not applicable	Not applicable	95% confidence intervals are reported for the total number of appointments required and the estimated total costs.

Abbreviations: BOA: British Orthopaedic Association

(a) A cost comparison with a UK NHS perspective which looks at the costs of 2 strategies with different quantities of follow-ups required. No QALYs.

(b) No inclusion of quality of life or other health outcomes; not all relevant costs are included as the costs of revision and other subsequent care were excluded Uses observational data that is not included in the clinical review.

(c) Follow up at 1, 5 and each subsequent 5 years after operation (previous BOA guideline)

(d) For ODEP 10a- rated combinations: follow up in the first year, at 7 years and 3 yearly thereafter in asymptomatic patients; For non ODEP 10a- rated combinations: follow up usually for the first 5 years, 2-yealry to 10 years and 3-yearly thereafter; patients over 75 years with ODEP 10a implants need not be routinely reviewed after the post-operative period (new BOA guidelines)

1.5.4 Unit costs

Relevant unit costs are provided below to aid consideration of cost effectiveness.

Table 3: Unit costs for hospital based professionals who may conduct follow up appointments

Hospital based profession	Pay Band	Cost per working hour
Occupational therapist/Physiotherapist	4-8b	£30-77
Nurse	4-8a	£28-62
Consultant surgeon	n/a	£107

Source: PSSRU 2017[13]

Table 4: Unit costs for an X-ray

Description	Unit cost
Direct access plain film X-ray	£25

Source: National Tariff Workbook 2016/17[45]

1.6 Evidence statements

1.6.1 Clinical evidence statements

No clinical evidence was identified.

1.6.2 Health economic evidence statements

One comparative cost analysis showed that follow up after total hip replacement based on the ODEP implant rating to be more expensive per person (£350 more per person) than follow up of all implant types in the 1st and 7th year and then 3-yearly thereafter. This analysis was assessed as partially applicable with potentially serious limitations.

1.7 The committee's discussion of the evidence

1.7.1 Interpreting the evidence

1.7.1.1 The outcomes that matter most

The critical outcomes include emergency reoperation and life expectancy. With 3 other critical outcomes divided into short- and long-term time points: quality of life, patient reported outcome measures (PROMs) and reoperation. Function and pain would be extracted if not included in a PROM. The most critical outcome was emergency reoperation, and this was designed to pick up follow-up regimens that do not notice people's increased pain, decreased function or asymptomatic complications to the point that an emergency reoperation is required. An ideal follow-up programme would facilitate well-timed revisions based on implant failure that cause people as little pain, reduced function and reduced quality of life as possible. Subjective outcomes that assess how people find the whole joint replacement surgery experience including the effects of follow-up were quality of life and PROMs. The 2 time points were to highlight 2 distinctive periods in the existence of a joint replacement. Within the first 2 years, the appointments exist to assess whether function is improving to the level expected after surgery, to assess if pain has reduced from the raised level in the post-surgical period, and to monitor the occurrence of adverse events. Recovery

after hip, knee and shoulder joint replacement has been demonstrated to stabilise and plateau within 2 years. The longer follow-up period still assesses pain and function as an indicator to how the joint replacement is working on an ongoing basis and a plain radiographic assessment of the joint may also be needed to evaluate the position and stability in the joint.

1.7.1.2 The quality of the evidence

No relevant clinical studies were found for this question.

1.7.1.3 Benefits and harms

Follow-up varies greatly across the NHS. While the committee agreed that there is universally orthopaedic team follow-up after the operation and the long term follow up is varied. A committee member indicated that his centre gives people 2 standard post-hospital discharge appointments with the orthopaedic team. The first at 2 weeks and the second at 8 weeks; people are then discharged from orthopaedic care if there are no complications at that point. These appointments are largely intended to evaluate wound healing and recovery from the operation. They also provide an indication as to whether further rehabilitation is needed to promote recovery. No regular monitoring appointments with the orthopaedic team happen after discharge from orthopaedic care. However, other centres offer regular follow-up appointments at varying time points and sometimes based on various factors such as the Orthopaedic Data Evaluation Panel (ODEP) rating of the implant. These appointments could be ongoing for many years.

The committee discussed arguments for and against regular follow-up appointments. The arguments against are that they may well be unnecessary as people tend to do well after joint replacement surgery and they might seem like an imposition on their time. In addition, if they are not necessary and people gain no benefit from them then it could be a cost-saving not to schedule them in. The arguments for include opportunities to pick up important asymptomatic complications such as bone lysis (osteolysis) afforded by scheduled follow-up appointments. It is possible these complications, if not spotted, could lead to very negative outcomes including fracture if left unchecked. However, asymptomatic complications are rare and it is unclear if follow-up appointments on that basis are cost-effective. A committee member also spoke about people who would not feel comfortable highlighting their difficulties to the GP. Scheduled follow-up appointments with the orthopaedic team could identify people who are in pain or have poor function and are not able or willing to get access to orthopaedic help outside of these scheduled appointments. People might feel abandoned if, after a number of years post-surgery, they have not interacted with the orthopaedic team for some time. In addition, follow-up appointments may encourage people to keep up with important functional targets and regular activities, such as exercise, to keep the joint working well. It was suggested that having scheduled follow up appointments period might encourage long term engagement with rehabilitation and other beneficial ways of living, but this is speculative.

There was some committee discussion on who would carry out the follow-up appointments. Primary care services including community physiotherapy and general practice could offer routine monitoring of people after joint replacement surgery. This may take the burden off acute services while also providing reassurance to people. It was acknowledged that training and support may be required for such a service to be provided.

The committee spoke about methods of surveillance appointments that could be used. Tele-monitoring is an option which might use video calls or telephone consultations. This may be a particularly valuable approach for people who live in more rural settings or those who face difficulties in getting to health services. The committee acknowledged that some operations

are performed in specialist centres that may be many miles from the person's home. Such remote monitoring may be valuable in that instance to reduce the inconvenience people face, while also providing the specialist consultation and surgical continuity from their health care providers.

The alternative to follow-up appointments is patient-directed follow-up. With this approach people present to a GP, physiotherapist, or occupational therapist as decided. If a problem is identified then they are referred back to the orthopaedic team. Primary care is currently the gateway to secondary care. It means that the GP would assess whether any symptoms relate to the joint replacement or other causes, and the orthopaedic team would be able to focus on those who are developing new or worsening pain, limp or loss of function related to their joint prosthesis rather than the majority of people who are living well with the joint replacement. The committee agreed there are advantages and disadvantages to patient-directed follow-up. Joint replacements can fail early, midterm, or indeed last for many years and patient-directed follow-up would be active in all these periods to pick up people in difficulty. Thus, people would be able to gain a referral if required and would not wait long periods for the next monitoring appointment. The disadvantage with this approach is that asymptomatic complications would only be picked up if discovered via a referral for a different symptomatic problem and the requirement to self-refer may give a feeling of being abandonment by the health care system.

As no evidence was found, the committee decided not to alter current practice. There are British Orthopaedic Association (BOA) guidelines on postoperative and long-term follow-up after total hip and knee replacement. These were drafted from expert consensus. The committee did not want to override these consensus recommendations with its own consensus recommendations given the lack of evidence.

The committee considered people who may find accessing healthcare more challenging through cognitive impairment, comorbidities, or difficulties with activities of daily living. The committee felt that currently, a person's carer, family member or friend is often a good judge to indicate whether, in everyday life, the individual's joint pain or function has changed. Thus the person's carer, family member or friend could accompany them to the GP, physiotherapist, or occupational therapist appointment and highlight the situation if it is unclear. It was therefore felt that no adaptation was required for the guidelines for this population.

The recommendation that monitoring is patient-led provides flexibility but also a pathway for people to seek assessment when required. This is not limited by patient characteristics and is available to all people who have had joint replacement surgery. Clinical decision-making may determine that some people need a different follow-up strategy depending on complications from their surgery or their individual characteristics. However, the recommendation is based on a minimal expectation. No evidence was found suggesting at-risk subgroups of people who need greater or lesser levels of surveillance.

1.7.2 Cost effectiveness and resource use

One health economic study was included in this review that was a cost comparison of the old and new British Orthopaedic Association (BOA) hip replacement follow-up guidelines. The study was limited, as it did not include health outcomes or costs outside of the actual follow-up sessions. After discussing the evidence, the committee agreed that one of the papers originally presented to the committee should be excluded given that the intervention effects were taken from a single Swedish observational study, and there were unreasonably large assumptions about using the same utility values over the time horizon. The UK SAFE study, due to be completed in the near future, will contain a Markov model which should provide an

insight into the cost-effectiveness of follow-up strategy for hip and knee replacements but not shoulder replacements.

Current practice is difficult to define for the different sites of surgery. The BOA has follow-up guidelines published for hip and knee replacement procedures although the committee acknowledged that these are not always adhered to. It seems that current practice is variable in accordance with local decision-making. A few committee members discussed that screening on a regular basis for all joint replacements to pick up problems in a low percentage of people would be unlikely to be cost effective. No recommendation could be made for regular follow-ups for the entire joint replacement population as this would be costly and resource intensive; furthermore there is no evidence to say that this would be clinically effective.

However, the committee also agreed that it would be bad practice not to provide follow-up sessions to people who experience new or worsening pain, limp or loss of function after their joint replacement. Approximately 20% of people experience ongoing pain after their knee replacement surgery. This would be the maximum proportion referred for follow-up. Referral to a member of the orthopaedic team is likely to happen through a GP in primary care. In areas where referral for those who experience new or worsening pain is current practice, the recommendation will not have any resource impact. However for other areas where it is not current practice, there may be a resource impact from an increase in referrals.

1.7.3 Other factors the committee took into account

The National Institute for Health Research (NIHR) Leeds Musculoskeletal Biomedical Research Unit is currently undertaking the UK SAFE: UK post Arthroplasty Follow-up recommendations project. It is a multi-layered study aimed to investigate the curtailing primary hip and knee arthroplasty follow-up services to deal with growing financial pressure. The aim of this is to examine the requirements for joint replacement follow-up and produce evidence and consensus-based recommendations as to how, when and on whom follow-up should be conducted. It does this through a systematic literature review, a retrospective cohort study that uses large national data sets including the Hospital Episode Statistics (HES) and the National Joint Registry (NJR), a prospective study investigating follow-up routines, a health economic analysis and Markov model utilising the data they find and create in the other investigative strands, and a Delphi consensus study involving 25-30 participants including patients, surgeons, GPs, and commissioners.

This project should lead to more nuanced recommendations on follow-up in people after hip and knee arthroplasty. This leaves a hole in the research around shoulder joint replacement; therefore, the committee decided to make a research recommendation for people having shoulder replacement surgery.

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Appendices

Appendix A: Review protocols

Table 5: Review protocol: long-term monitoring

ID	Field	Content
0.	PROSPERO registration number	Not registered
1.	Review title	Long-term monitoring after joint replacement surgery
2.	Review question	In adults having primary elective joint replacement, what would be the optimal timing of follow-up or surveillance appointments? In adults having primary elective joint replacement, who should carry out follow-up or surveillance appointments? In adults having primary elective joint replacement, should x-rays be undertaken for all follow-up or surveillance appointments?
3.	Objective	It is currently unclear what the most effective monitoring strategy is for people who have had joint replacement surgery. There are a number of variables in this practice: how often and for what length of time should someone should be monitored, who should undertake the monitoring appointments and whether this should change over time after surgery, and whether x-rays should be undertaken for each appointment. The role of these appointments change. In the first 2 years after surgery, the appointments exist to assess whether function is improving to the level expected after joint replacement, to assess if pain has reduced from the raised level in the post-surgical period, and to monitor the occurrence of adverse events. After 2 years, the benefits of joint replacement are likely to have plateaued. Pain and function would still be monitored and addressed with an assessment of whether the joint replacement should be revised. In addition, these appointments could assess the presence of asymptomatic complications, for example bone lysis; x-rays are required for this assessment. This review seeks to find the most effective follow-up or surveillance strategy. It also seeks to establish when someone should be discharged from orthopaedic care. This would be indicated through the strategy in terms of who should carry out follow-up or surveillance appointments. If the strategy indicates someone outside the orthopaedic team would carry out the follow-up or surveillance appointments, then this would also indicate that it is possible to discharge the person from orthopaedic care at that time.
4.	Searches	The following databases will be searched: Cochrane Central Register of Controlled Trials (CENTRAL)

ID	Field	Content
		Cochrane Database of Systematic Reviews (CDSR) Embase MEDLINE Searches will be restricted by: English language Human studies Letters and comments are excluded. Other searches: Inclusion lists of relevant systematic reviews will be checked by the reviewer. The searches may be re-run 6 weeks before final committee meeting and further studies retrieved for inclusion if relevant. The full search strategies will be published in the final review.
5.	Condition or domain being studied	Primary elective shoulder joint replacement surgery
6.	Population	Inclusion: Adults who have undergone primary hip, knee or shoulder joint replacement. Exclude studies including people meeting any of the following criteria: Adults having joint replacement as immediate treatment following fracture Adults having revision joint replacement. Adults having joint replacement as treatment for primary or secondary cancer affecting the bones.
7.	Intervention/Exposure/Test	Follow up/surveillance strategy Interventions to be separated by: Different time points starting from initial follow-up /surveillance appointment

ID	Field	Content
		The healthcare professionals carrying out the follow-up /surveillance appointments, for example, member of the orthopaedic team, GP or physiotherapist. Whether routine x-rays are utilised for each follow-up /surveillance monitoring appointment.
8.	Comparator/Reference standard/Confounding factors	Comparison of interventions
9.	Types of study to be included	Systematic reviews RCTs If no well-conducted RCTs are available, then observational studies with multivariate analysis will be investigated.
10.	Other exclusion criteria	Non-English language studies. Abstracts will be excluded as it is expected there will be sufficient full text published studies available.
11.	Context	N/A
12.	Primary outcomes (critical outcomes)	Emergency reoperation (dichotomous) Mortality: life expectancy (time to event) Quality of life at 2 years after surgery, at the longest time point (at least 4 years after surgery) (continuous) Patient Reported Outcome Measures (PROMs) at 2 years after surgery, at the longest time point (at least 4 years after surgery; continuous) Reoperation (including revision) at 2 years after surgery, at the longest time point (at least 4 years after surgery; dichotomous)
13.	Secondary outcomes (important outcomes)	To be extracted when not included within an extracted PROM: Function at 6 weeks or earlier, later than 6 weeks up to 1 year, at least 2 years (continuous) Pain at 6 weeks or earlier, later than 6 weeks up to 1 year, at least 2 years (continuous)
14.	Data extraction (selection and coding)	EndNote will be used for reference management, sifting, citations and bibliographies. Titles and/or abstracts of studies retrieved using the search strategy and those from additional sources will be screened for inclusion. The full text of potentially eligible studies will be retrieved and will be assessed for eligibility in line with the criteria outlined above. 10% of the abstracts will be reviewed by two reviewers, with any disagreements resolved by discussion or, if necessary, a third independent reviewer.

ID	Field	Content
		An in-house developed database; EviBase, will be used for data extraction. A standardised form is followed to extract data from studies (see Developing NICE guidelines: the manual section 6.4) and for undertaking assessment of study quality. Summary evidence tables will be produced including information on: study setting; study population and participant demographics and baseline characteristics; details of the intervention and control interventions; study methodology' recruitment and missing data rates; outcomes and times of measurement; critical appraisal ratings. A second reviewer will quality assure the extracted data. Discrepancies will be identified and resolved through discussion (with a third reviewer where necessary).
15.	Risk of bias (quality) assessment	Risk of bias will be assessed using the appropriate checklist as described in Developing NICE guidelines: the manual. For Intervention reviews the following checklist will be used according to study design being assessed: Systematic reviews: Risk of Bias in Systematic Reviews (ROBIS) Randomised Controlled Trial: Cochrane RoB (2.0) Disagreements between the review authors over the risk of bias in particular studies will be resolved by discussion, with involvement of a third review author where necessary.
16.	Strategy for data synthesis	Where possible, data will be meta-analysed. Pairwise meta-analyses will be performed using Cochrane Review Manager (RevMan5) to combine the data given in all studies for each of the outcomes stated above. A fixed effect meta-analysis, with weighted mean differences for continuous outcomes and risk ratios for binary outcomes will be used, and 95% confidence intervals will be calculated for each outcome. Heterogeneity between the studies in effect measures will be assessed using the I^2 statistic and visually inspected. We will consider an I^2 value greater than 50% indicative of substantial heterogeneity. Sensitivity analyses will be conducted based on pre-specified subgroups using stratified meta-analysis to explore the heterogeneity in effect estimates. If this does not explain the heterogeneity, the results will be presented using random-effects. GRADE pro will be used to assess the quality of each outcome, taking into account individual study quality and the meta-analysis results. The 4 main quality elements (risk of bias, indirectness, inconsistency and imprecision) will be appraised for each outcome. If the population included in an individual study includes children aged under 12, it will be included if the majority of the population is aged over 12, and downgraded for indirectness if the overlap into those aged less than 12 is greater than 20%. Publication bias is tested for when there are more than 5 studies for an outcome.

ID	Field	Content			
		Other bias will only be taken into consideration in the quality assessment if it is apparent. Where meta-analysis is not possible, data will be presented and quality assessed individually per outcome. If sufficient data is available to make a network of treatments, WinBUGS will be used for network meta-analysis.			
17.	Analysis of sub-groups	Site of joint replacement: knee, shoulder, hip Age: working age, above working age Appointments type: virtual, in person Grade /experience of team member undertaking review Implant rating: ODEP <10a, ODEP ≥10aAge			
18.	Type and method of review	☒	Intervention		
		☐	Diagnostic		
		☐	Prognostic		
		☐	Qualitative		
		☐	Epidemiologic		
		☐	Service Delivery		
		☐	Other (please specify)		
19.	Language	English			
20.	Country	England			
21.	Anticipated or actual start date	16/03/19			
22.	Anticipated completion date	20/03/20			
23.	Stage of review at time of this submission	Review stage		Started	Completed
		Preliminary searches		☑	☐
		Piloting of the study selection process		☑	☐
		Formal screening of search results against eligibility criteria		☐	☐

ID	Field	Content		
		Data extraction	☐	☐
		Risk of bias (quality) assessment	☐	☐
		Data analysis	☐	☐
24.	Named contact	5a. Named contact National Guideline Centre 5b Named contact e-mail Headches@nice.org.uk 5e Organisational affiliation of the review National Institute for Health and Care Excellence (NICE) and the National Guideline Centre		
25.	Review team members	From the National Guideline Centre: Carlos Sharpin [Guideline lead] Alex Allen [Senior Systematic Reviewer] Rafina Yarde [Systematic reviewer] Robert King [Health economist] Agnès Cuyàs [Information specialist] Eleanor Priestnall [Project Manager]		
26.	Funding sources/sponsor	This systematic review is being completed by the National Guideline Centre which receives funding from NICE.		
27.	Conflicts of interest	All guideline committee members and anyone who has direct input into NICE guidelines (including the evidence review team and expert witnesses) must declare any potential conflicts of interest in line with NICE's code of practice for declaring and dealing with conflicts of interest. Any relevant interests, or changes to interests, will also be declared publicly at the start of each guideline committee meeting. Before each meeting, any potential conflicts of interest will be considered by the guideline committee Chair and a senior member of the development team. Any decisions to exclude a person from all or part of a meeting will be documented. Any changes to a member's declaration of interests will be recorded in the minutes of the meeting. Declarations of interests will be published with the final guideline.		
28.	Collaborators	Development of this systematic review will be overseen by an advisory committee who will use the review to inform the		

ID	Field	Content	
		development of evidence-based recommendations in line with section 3 of Developing NICE guidelines: the manual. Members of the guideline committee are available on the NICE website: [NICE guideline webpage].	
29.	Other registration details		
30.	Reference/URL for published protocol		
31.	Dissemination plans	NICE may use a range of different methods to raise awareness of the guideline. These include standard approaches such as: notifying registered stakeholders of publication publicising the guideline through NICE's newsletter and alerts issuing a press release or briefing as appropriate, posting news articles on the NICE website, using social media channels, and publicising the guideline within NICE.	
32.	Keywords	Joint replacement surgery, arthroplasty, surveillance, monitoring,	
33.	Details of existing review of same topic by same authors	N/A	
34.	Current review status	☒	Ongoing
		☐	Completed but not published
		☐	Completed and published
		☐	Completed, published and being updated
		☐	Discontinued
35..	Additional information	N/A	
36.	Details of final publication	www.nice.org.uk	

Table 6: Health economic review protocol

Review question	All questions – health economic evidence
Objectives	To identify health economic studies relevant to any of the review questions.
Search criteria	• Populations, interventions and comparators must be as specified in the clinical review protocol above. • Studies must be of a relevant health economic study design (cost–utility analysis, cost-effectiveness analysis, cost–benefit analysis, cost–consequences analysis, comparative cost analysis). • Studies must not be a letter, editorial or commentary, or a review of health economic evaluations. (Recent reviews will be ordered although not reviewed. The bibliographies will be checked for relevant studies, which will then be ordered.) • Unpublished reports will not be considered unless submitted as part of a call for evidence. • Studies must be in English.
Search strategy	A health economic study search will be undertaken using population-specific terms and a health economic study filter – see appendix B below.
Review strategy	Studies not meeting any of the search criteria above will be excluded. Studies published before 2003, abstract-only studies and studies from low or middle-income countries (for example, most non-OECD countries) or the USA will also be excluded. Each remaining study will be assessed for applicability and methodological limitations using the NICE economic evaluation checklist which can be found in appendix H of Developing NICE guidelines: the manual (2014).[44] **Inclusion and exclusion criteria** • If a study is rated as both 'Directly applicable' and with 'Minor limitations', then it will be included in the guideline. A health economic evidence table will be completed and it will be included in the health economic evidence profile. • If a study is rated as either 'Not applicable' or with 'Very serious limitations', then it will usually be excluded from the guideline. If it is excluded then a health economic evidence table will not be completed and it will not be included in the health economic evidence profile. • If a study is rated as 'Partially applicable' with 'Potentially serious limitations' or both, then there is discretion over whether it should be included. **Where there is discretion** The health economist will make a decision based on the relative applicability and quality of the available evidence for that question, in discussion with the guideline committee if required. The ultimate aim is to include health economic studies that are helpful for decision-making in the context of the guideline and the current NHS setting. If several studies are considered of sufficiently high applicability and methodological quality that they could all be included, then the health economist, in discussion with the committee if required, may decide to include only the most applicable studies and to exclude selectively the remaining studies. All studies excluded based on applicability or methodological limitations will be listed with explanation in the excluded health economic studies appendix below. The health economist will be guided by the following hierarchies. *Setting:* • UK NHS (most applicable). • OECD countries with predominantly public health insurance systems (for example, France, Germany, Sweden). • OECD countries with predominantly private health insurance systems (for example,

	Switzerland). • Studies set in non-OECD countries or in the USA will be excluded before being assessed for applicability and methodological limitations. *Health economic study type:* • Cost–utility analysis (most applicable). • Other type of full economic evaluation (cost–benefit analysis, cost-effectiveness analysis, cost–consequences analysis). • Comparative cost analysis. • Non-comparative cost analyses including cost-of-illness studies will be excluded before being assessed for applicability and methodological limitations. *Year of analysis:* • The more recent the study, the more applicable it will be. • Studies published in 2003 or later but that depend on unit costs and resource data entirely or predominantly before 2003 will be rated as 'Not applicable'. • Studies published before 2003 will be excluded before being assessed for applicability and methodological limitations. *Quality and relevance of effectiveness data used in the health economic analysis:* • The more closely the clinical effectiveness data used in the health economic analysis match with the outcomes of the studies included in the clinical review the more useful the analysis will be for decision-making in the guideline.

Appendix B: Literature search strategies

The literature searches for this review are detailed below and complied with the methodology outlined in Developing NICE guidelines: the manual.[44]

For more detailed information, please see the Methodology Review.

B.1 Clinical search literature search strategy

Searches were constructed using a PICO framework where population (P) terms were combined with Intervention (I) and in some cases Comparison (C) terms. Outcomes (O) are rarely used in search strategies for interventions as these concepts may not be well described in title, abstract or indexes and therefore difficult to retrieve. Search filters were applied to the searches where appropriate.

Table 7: Database date parameters and filters used

Database	Dates searched	Search filter used
Medline (OVID)	1946 – 01 May 2019	Exclusions Randomised controlled trials Systematic review studies Observational studies
Embase (OVID)	1974 – 01 May 2019	Exclusions Randomised controlled trials Systematic review studies Observational studies
The Cochrane Library (Wiley)	Cochrane Reviews to 2019 Issue 5 of 12 CENTRAL to 2019 Issue 5 of 12	None

Medline (Ovid) search terms

1.	arthroplasty/ or arthroplasty, replacement/ or arthroplasty, replacement, hip/ or arthroplasty, replacement, knee/ or arthroplasty, replacement, shoulder/ or hemiarthroplasty/
2.	joint prosthesis/ or hip prosthesis/ or knee prosthesis/ or shoulder prosthesis/
3.	((joint* or knee* or shoulder* or hip*) adj5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)).ti,ab.
4.	or/1-3
5.	letter/
6.	editorial/
7.	news/
8.	exp historical article/
9.	Anecdotes as Topic/
10.	comment/
11.	case report/
12.	(letter or comment*).ti.
13.	or/5-12
14.	randomized controlled trial/ or random*.ti,ab.
15.	13 not 14
16.	animals/ not humans/

17.	exp Animals, Laboratory/
18.	exp Animal Experimentation/
19.	exp Models, Animal/
20.	exp Rodentia/
21.	(rat or rats or mouse or mice).ti.
22.	or/15-21
23.	4 not 22
24.	limit 23 to English language
25.	Monitoring, physiologic/
26.	(monitoring or followup or follow up or surveillance).ti.
27.	((followup or follow* up or surveillance or monitor*) adj2 (strateg* or program* or regular* or routine* or periodic* or schedul* or frequen* or timing or long term or longterm or services)).ti,ab.
28.	((followup or follow* up or surveillance or monitoring) adj2 (specialist* or physician* or nurse* or surgeon* or general practi* or GP or family practi* or doctor or orthopaedic or physiotherapist*)).ti,ab.
29.	((followup or follow* up or surveillance or monitoring) adj2 (x-ray* or xray* or x-radiation* or xradiation* or roentgen ray* or radiograph*)).ti,ab.
30.	or/25-29
31.	24 and 30
32.	randomized controlled trial.pt.
33.	controlled clinical trial.pt.
34.	randomi#ed.ti,ab.
35.	placebo.ab.
36.	randomly.ti,ab.
37.	Clinical Trials as topic.sh.
38.	trial.ti.
39.	or/32-38
40.	Meta-Analysis/
41.	exp Meta-Analysis as Topic/
42.	(meta analy* or metanaly* or metaanaly* or meta regression).ti,ab.
43.	((systematic* or evidence*) adj3 (review* or overview*)).ti,ab.
44.	(reference list* or bibliograph* or hand search* or manual search* or relevant journals).ab.
45.	(search strategy or search criteria or systematic search or study selection or data extraction).ab.
46.	(search* adj4 literature).ab.
47.	(medline or pubmed or cochrane or embase or psychlit or psyclit or psychinfo or psycinfo or cinahl or science citation index or bids or cancerlit).ab.
48.	cochrane.jw.
49.	((multiple treatment* or indirect or mixed) adj2 comparison*).ti,ab.
50.	or/40-49
51.	Epidemiologic studies/
52.	Observational study/
53.	exp Cohort studies/
54.	(cohort adj (study or studies or analys* or data)).ti,ab.
55.	((follow up or observational or uncontrolled or non randomi#ed or epidemiologic*) adj (study or studies or data)).ti,ab.

56.	((longitudinal or retrospective or prospective or cross sectional) and (study or studies or review or analys* or cohort* or data)).ti,ab.
57.	Controlled Before-After Studies/
58.	Historically Controlled Study/
59.	Interrupted Time Series Analysis/
60.	(before adj2 after adj2 (study or studies or data)).ti,ab.
61.	or/51-60
62.	exp case control study/
63.	case control*.ti,ab.
64.	or/62-63
65.	61 or 64
66.	Cross-sectional studies/
67.	(cross sectional and (study or studies or review or analys* or cohort* or data)).ti,ab.
68.	or/66-67
69.	61 or 68
70.	61 or 64 or 68
71.	31 and (39 or 50 or 70)

Embase (Ovid) search terms

1.	*arthroplasty/ or *replacement arthroplasty/ or *hip replacement/ or *knee replacement/ or *shoulder replacement/ or *hemiarthroplasty/
2.	*joint prosthesis/ or *hip prosthesis/ or *knee prosthesis/ or *shoulder prosthesis/
3.	((joint* or knee* or shoulder* or hip*) adj5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)).ti,ab.
4.	or/1-3
5.	letter.pt. or letter/
6.	note.pt.
7.	editorial.pt.
8.	case report/ or case study/
9.	(letter or comment*).ti.
10.	or/5-9
11.	randomized controlled trial/ or random*.ti,ab.
12.	10 not 11
13.	animal/ not human/
14.	nonhuman/
15.	exp Animal Experiment/
16.	exp Experimental Animal/
17.	animal model/
18.	exp Rodent/
19.	(rat or rats or mouse or mice).ti.
20.	or/12-19
21.	4 not 20
22.	limit 21 to English language
23.	patient monitoring/
24.	(monitoring or followup or follow up or surveillance).ti.
25.	((followup or follow* up or surveillance or monitor*) adj2 (strateg* or program* or regular* or routine* or periodic* or schedul* or frequen* or timing or long term or

	longterm or services)).ti,ab.
26.	((followup or follow* up or surveillance or monitoring) adj2 (specialist* or physician* or nurse* or surgeon* or general practi* or GP or family practi* or doctor or orthopaedic or physiotherapist*)).ti,ab.
27.	((followup or follow* up or surveillance or monitoring) adj2 (x-ray* or xray* or x-radiation* or xradiation* or roentgen ray* or radiograph*)).ti,ab.
28.	or/23-27
29.	22 and 28
30.	random*.ti,ab.
31.	factorial*.ti,ab.
32.	(crossover* or cross over*).ti,ab.
33.	((doubl* or singl*) adj blind*).ti,ab.
34.	(assign* or allocat* or volunteer* or placebo*).ti,ab.
35.	crossover procedure/
36.	single blind procedure/
37.	randomized controlled trial/
38.	double blind procedure/
39.	or/30-38
40.	systematic review/
41.	meta-analysis/
42.	(meta analy* or metanaly* or metaanaly* or meta regression).ti,ab.
43.	((systematic* or evidence*) adj3 (review* or overview*)).ti,ab.
44.	(reference list* or bibliograph* or hand search* or manual search* or relevant journals).ab.
45.	(search strategy or search criteria or systematic search or study selection or data extraction).ab.
46.	(search* adj4 literature).ab.
47.	(medline or pubmed or cochrane or embase or psychlit or psyclit or psychinfo or psycinfo or cinahl or science citation index or bids or cancerlit).ab.
48.	cochrane.jw.
49.	((multiple treatment* or indirect or mixed) adj2 comparison*).ti,ab.
50.	or/40-49
51.	Clinical study/
52.	Observational study/
53.	family study/
54.	longitudinal study/
55.	retrospective study/
56.	prospective study/
57.	cohort analysis/
58.	follow-up/
59.	cohort*.ti,ab.
60.	58 and 59
61.	(cohort adj (study or studies or analys* or data)).ti,ab.
62.	((follow up or observational or uncontrolled or non randomi#ed or epidemiologic*) adj (study or studies or data)).ti,ab.
63.	((longitudinal or retrospective or prospective or cross sectional) and (study or studies or review or analys* or cohort* or data)).ti,ab.
64.	(before adj2 after adj2 (study or studies or data)).ti,ab.

65.	or/51-57,60-64
66.	exp case control study/
67.	case control*.ti,ab.
68.	or/66-67
69.	65 or 68
70.	cross-sectional study/
71.	(cross sectional and (study or studies or review or analys* or cohort* or data)).ti,ab.
72.	or/70-71
73.	65 or 72
74.	65 or 68 or 72
75.	29 and (39 or 50 or 74)

Cochrane Library (Wiley) search terms

#1.	MeSH descriptor: [Arthroplasty] this term only
#2.	MeSH descriptor: [Arthroplasty, Replacement] this term only
#3.	MeSH descriptor: [Arthroplasty, Replacement, Hip] this term only
#4.	MeSH descriptor: [Arthroplasty, Replacement, Knee] this term only
#5.	MeSH descriptor: [Arthroplasty, Replacement, Shoulder] this term only
#6.	MeSH descriptor: [Hemiarthroplasty] this term only
#7.	(or #1-#6)
#8.	MeSH descriptor: [Joint Prosthesis] this term only
#9.	MeSH descriptor: [Hip Prosthesis] this term only
#10.	MeSH descriptor: [Knee Prosthesis] this term only
#11.	MeSH descriptor: [Shoulder Prosthesis] this term only
#12.	(or #8-#11)
#13.	((joint* or knee* or shoulder* or hip*) near/5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)):ti,ab
#14.	(or #7, #12-#13)
#15.	MeSH descriptor: [Monitoring, Physiologic] this term only
#16.	(monitoring or followup or follow up or surveillance):ti
#17.	((followup or follow* up or surveillance or monitor*) near/2 (strateg* or program* or regular* or routine* or periodic* or schedul* or frequen* or timing or long term or longterm or services)):ti,ab
#18.	((followup or follow* up or surveillance or monitoring) near/2 (specialist* or physician* or nurse* or surgeon* or general practi* or GP or family practi* or doctor or orthopaedic or physiotherapist*)):ti,ab
#19.	((followup or follow* up or surveillance or monitoring) near/2 (x-ray* or xray* or x-radiation* or xradiation* or roentgen ray* or radiograph*)):ti,ab
#20.	(OR #15-#19)
#21.	#14 AND #20

B.2 Health Economics literature search strategy

Health economic evidence was identified by conducting a broad search relating to joint replacement population in NHS Economic Evaluation Database (NHS EED – this ceased to be updated after March 2015) and the Health Technology Assessment database (HTA) with no date restrictions. NHS EED and HTA databases are hosted by the Centre for Research and Dissemination (CRD). Additional health economics searches were run in Medline and Embase.

Table 8: Database date parameters and filters used

Database	Dates searched	Search filter used
Medline	2014 – 01 May 2019	Exclusions Health economics studies
Embase	2014 – 01 May 2019	Exclusions Health economics studies
Centre for Research and Dissemination (CRD)	HTA - Inception – 01 May 2019 NHSEED - Inception to March 2015	None

Medline (Ovid) search terms

1.	arthroplasty/ or arthroplasty, replacement/ or arthroplasty, replacement, hip/ or arthroplasty, replacement, knee/ or arthroplasty, replacement, shoulder/ or hemiarthroplasty/
2.	joint prosthesis/ or hip prosthesis/ or knee prosthesis/ or shoulder prosthesis/
3.	((joint* or knee* or shoulder* or hip*) adj5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)).ti,ab.
4.	or/1-3
5.	letter/
6.	editorial/
7.	news/
8.	exp historical article/
9.	Anecdotes as Topic/
10.	comment/
11.	case report/
12.	(letter or comment*).ti.
13.	or/5-12
14.	randomized controlled trial/ or random*.ti,ab.
15.	13 not 14
16.	animals/ not humans/
17.	exp Animals, Laboratory/
18.	exp Animal Experimentation/
19.	exp Models, Animal/
20.	exp Rodentia/
21.	(rat or rats or mouse or mice).ti.
22.	or/15-21
23.	4 not 22
24.	limit 23 to English language
25.	Economics/
26.	Value of life/
27.	exp "Costs and Cost Analysis"/
28.	exp Economics, Hospital/
29.	exp Economics, Medical/
30.	Economics, Nursing/
31.	Economics, Pharmaceutical/

32.	exp "Fees and Charges"/
33.	exp Budgets/
34.	budget*.ti,ab.
35.	cost*.ti.
36.	(economic* or pharmaco?economic*).ti.
37.	(price* or pricing*).ti,ab.
38.	(cost* adj2 (effective* or utilit* or benefit* or minimi* or unit* or estimat* or variable*)).ab.
39.	(financ* or fee or fees).ti,ab.
40.	(value adj2 (money or monetary)).ti,ab.
41.	or/25-40
42.	24 and 41

Embase (Ovid) search terms

1.	*arthroplasty/ or *replacement arthroplasty/ or *hip replacement/ or *knee replacement/ or *shoulder replacement/ or *hemiarthroplasty/
2.	*joint prosthesis/ or *hip prosthesis/ or *knee prosthesis/ or *shoulder prosthesis/
3.	((joint* or knee* or shoulder* or hip*) adj5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)).ti,ab.
4.	or/1-3
5.	letter.pt. or letter/
6.	note.pt.
7.	editorial.pt.
8.	case report/ or case study/
9.	(letter or comment*).ti.
10.	or/5-9
11.	randomized controlled trial/ or random*.ti,ab.
12.	10 not 11
13.	animal/ not human/
14.	nonhuman/
15.	exp Animal Experiment/
16.	exp Experimental Animal/
17.	animal model/
18.	exp Rodent/
19.	(rat or rats or mouse or mice).ti.
20.	or/12-19
21.	4 not 20
22.	limit 21 to English language
23.	health economics/
24.	exp economic evaluation/
25.	exp health care cost/
26.	exp fee/
27.	budget/

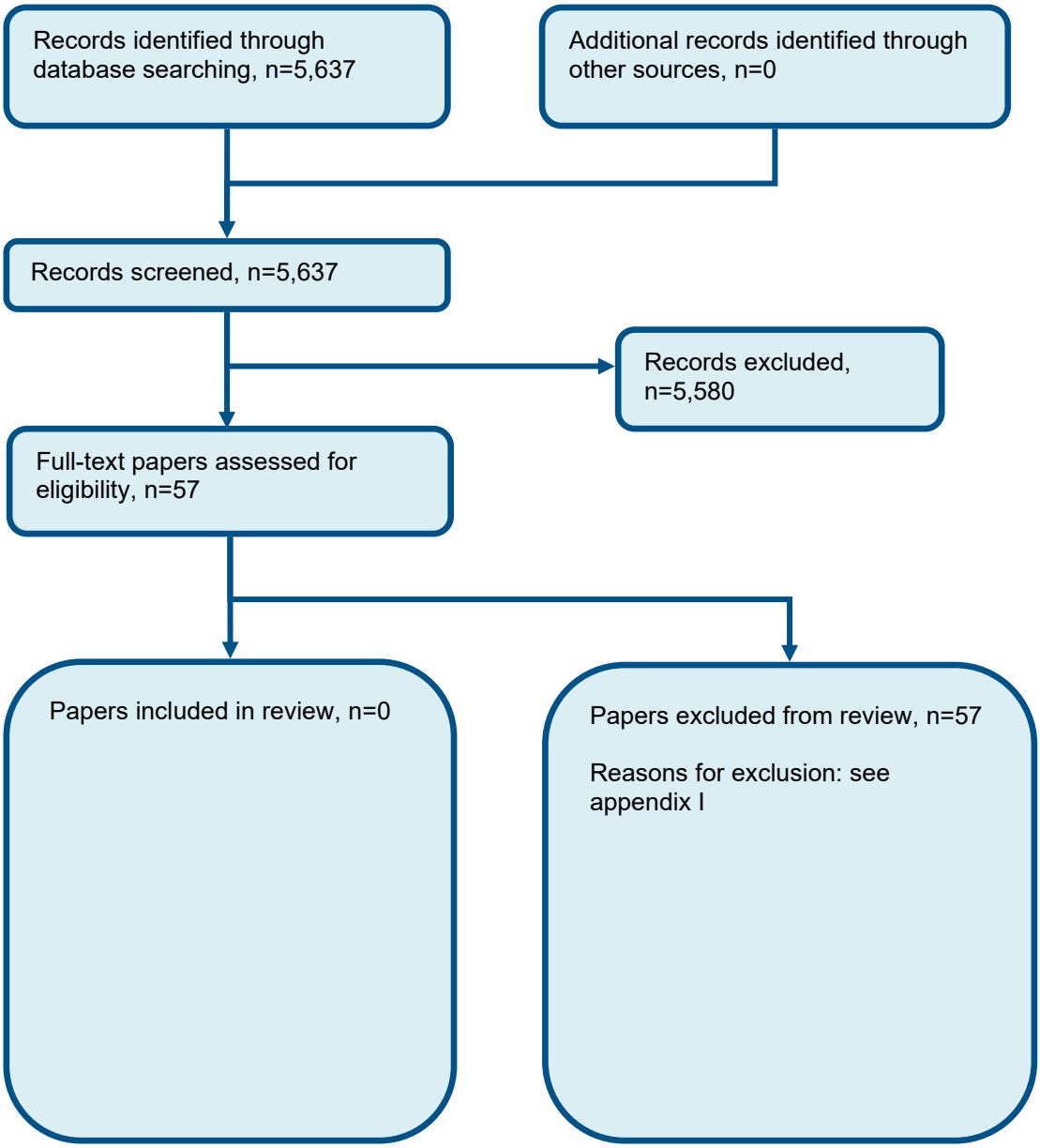
28.	funding/
29.	budget*.ti,ab.
30.	cost*.ti.
31.	(economic* or pharmaco?economic*).ti.
32.	(price* or pricing*).ti,ab.
33.	(cost* adj2 (effective* or utilit* or benefit* or minimi* or unit* or estimat* or variable*)).ab.
34.	(financ* or fee or fees).ti,ab.
35.	(value adj2 (money or monetary)).ti,ab.
36.	or/23-35
37.	22 and 36

NHS EED and HTA (CRD) search terms

#1.	MeSH DESCRIPTOR arthroplasty
#2.	MeSH DESCRIPTOR arthroplasty, replacement
#3.	MeSH DESCRIPTOR arthroplasty, replacement, hip
#4.	MeSH DESCRIPTOR arthroplasty, replacement, knee
#5.	MeSH DESCRIPTOR arthroplasty, replacement, shoulder
#6.	MeSH DESCRIPTOR hemiarthroplasty
#7.	MeSH DESCRIPTOR joint prosthesis
#8.	MeSH DESCRIPTOR hip prosthesis
#9.	MeSH DESCRIPTOR knee prosthesis
#10.	MeSH DESCRIPTOR shoulder prosthesis
#11.	(((joint* or knee* or shoulder* or hip*) adj5 (surger* or replace* or prosthe* or endoprosthe* or implant* or artificial or arthroplast* or hemiarthroplast*)))
#12.	(#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11) IN NHSEED
#13.	(#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11) IN HTA

Appendix C: Clinical evidence selection

Figure 1: Flow chart of clinical study selection for the review of long-term monitoring



Appendix D: Clinical evidence tables

No clinical evidence was identified.

Appendix E: Forest plots

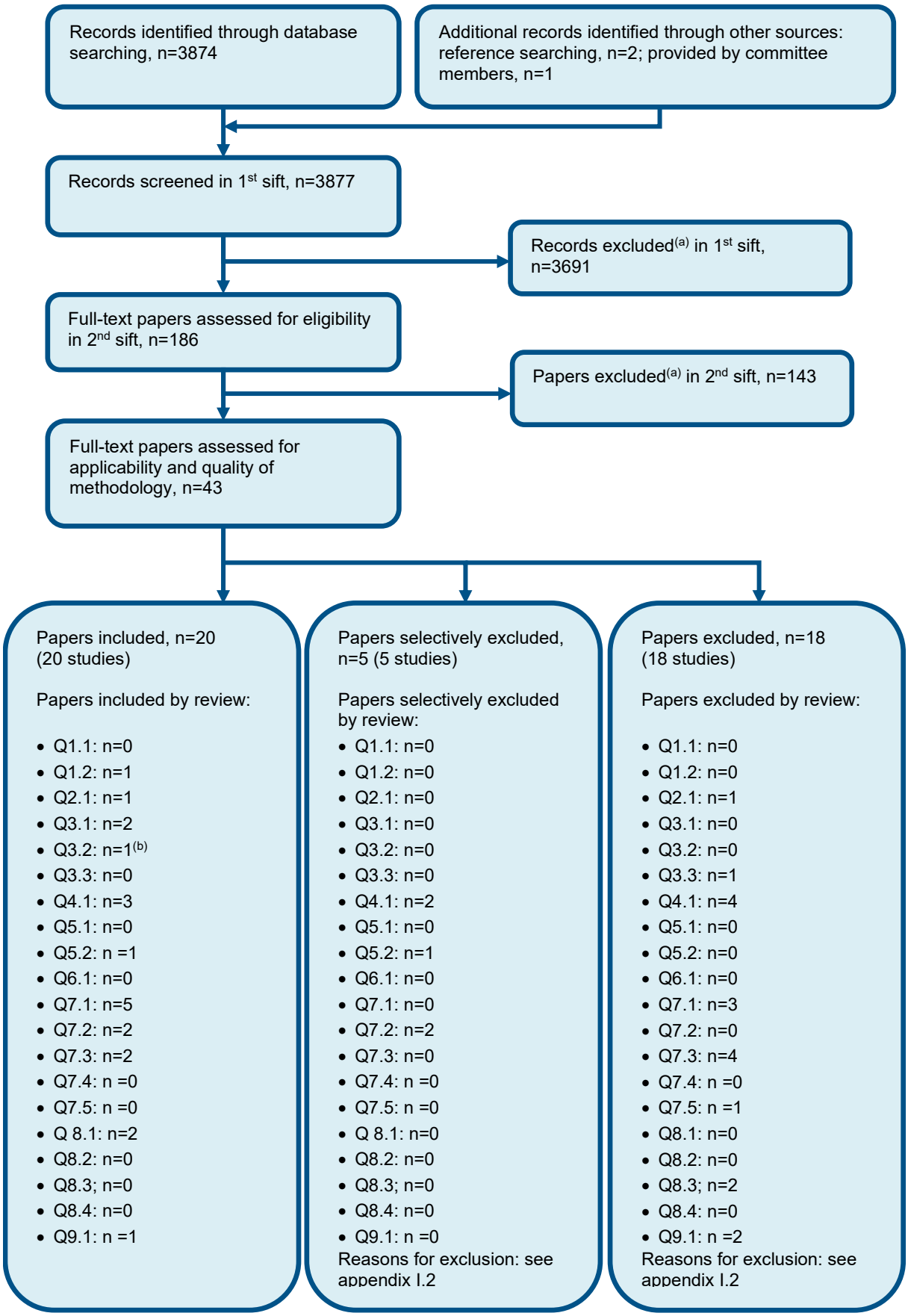
No clinical evidence was identified.

Appendix F: GRADE tables

No clinical evidence was identified

Appendix G: Health economic evidence selection

Figure 2: Flow chart of health economic study selection for the guideline



a) Non-relevant population, intervention, comparison, design or setting; non-English language
b) One study was applicable to both Q3.1 and Q3.2

Appendix H: Health economic evidence tables

Study	Roberts 2016[50]		
Study details	**Population & interventions**	**Costs**	**Cost effectiveness**
Economic analysis: Comparative costing **Study design:** Cohort model **Approach to analysis:** Simple cohort model simulating the costs of the old and new BOA follow up guidelines **Perspective:** UK NHS perspective **Time horizon**: Lifetime assuming 16.8 years life expectancy for the mean cohort age	**Population:** People on the NJR who underwent primary THR in England and Wales in 2012 **Cohort settings:** 74,419 people Mean age: 69.7 for females and 67.2 for males Male: 40% **Intervention 1:** Follow up at 1, 5 and each subsequent 5 years after operation (previous BOA guideline) **Intervention 2:** ODEP 10a- rated combination: follow up in the first year, at 7 years and 3 yearly thereafter in asymptomatic patients Non ODEP 10a- rated combination: follow up usually for the first 5 years, 2-yearly to 10 years and 3-yearly thereafter Patients over 75 years with ODEP 10a implants need not be routinely reviewed after the post-operative period (new BOA guidelines)	**Total costs (mean per patient):** 1: £318 2. £668 (£295 for a 10a implant and £720 for non-10a implant) Incremental (2-1): Intervention 2 costs £350 more per person **Currency & cost year:** 2014 UK pounds **Cost components incorporated:** The cost of a follow up appointment in 2012 which was estimated at £83	The overall cost of following up a patient is more expensive under the new BOA guidelines. However, for non-10a implants the new guideline is cheaper. **Analysis of uncertainty:** 95% confidence intervals were presented for the total number of appointments required and the total cost per arm but not for incremental costs
Data sources			
Health outcomes: Only used as part of the baseline cost calculations; cumulative revision rate reported up to 9 years after operation from the NJR 2012 and extrapolated until 16 years by assuming a 0.539% mean annual increase **Population:** All patients on the NJR who underwent THR in 2012 **Cost sources:** The 2014/15 National Tariff Payment System. The cost of a single follow up appointment was assumed to be the same as a standard NHS follow up tariff.			
Comments			
Source of funding: NR **Limitations:** No inclusion of quality of life or other health outcomes; not all relevant costs are included as the costs of revision and other subsequent care were excluded. Uses observational data that is not included in the clinical review.			

Overall applicability:[(c)] Partially applicable **Overall quality:**[(d)] Potentially serious limitations

Abbreviations: BOA: British Orthopaedic Association; NJR: National Joint Registry; NR: not reported; ODEP: Orthopaedic Data Evaluation Panel; THR: total hip replacement
(a) Directly applicable / Partially applicable / Not applicable
(b)*Minor limitations / Potentially serious limitations / Very serious limitations*

Appendix I: Excluded studies

I.1 Excluded clinical studies

Table 9: Studies excluded from the clinical review

Study	Exclusion reason
Abbas 2018[1]	Not a comparison of monitoring programs
Aleem 2011[2]	Study investigating compliance with follow-up program
Babcock 1994[3]	Not a comparison of monitoring programs
Balakrishnan 2010[4]	Not a comparison of monitoring programs
Berry 2001[5]	Review of venous thromboembolic disease after joint replacement
Bhatia 2003[6]	Case series rather than a comparison of monitoring strategies
Brothers 1997[8]	Not a comparison of monitoring programs
Carothers 2013[9]	Not a comparison of monitoring programs
Chaplin 2013[10]	Not a comparison of monitoring programs
Choi 2015[11]	Incorrect comparison
Clohisy 2008[12]	Literature review
De pablo 2006[14]	Not a comparison of monitoring programs
Friedman 2001[15]	Study investigating electronic chart review for surveillance
Gioe 2009[16]	Comparison of patient self-report outcomes and physician reported outcomes
Goggin 2009[17]	Not a comparison of monitoring programs
Grammatico-guillon 2014[18]	Not a comparison of monitoring programs
Hacking 2010[19]	Not a comparison of monitoring programs
Hardoon 2006[20]	Monitoring system for implant brands
Harrison 2009[21]	Not a systematic review or primary study
Huang 2017[22]	Not English language
Huenger 2005[23]	Not a comparison of monitoring programs
Jacobs 2015[24]	Not a comparison of monitoring programs
Johnston 1973[25]	Non comparative study
Keeney 2012[26]	Study investigating outcomes of routine follow-up
King 2004[27]	Incorrect comparison
Kingsbury 2016[28]	Inappropriate comparison
Large 2014[29]	Not a comparison of long term monitoring
Laumonerie 2017[30]	Systematic review to find the rate of reoperation to inform follow-up
Lonner 1998[31]	Case series rather than a comparison of monitoring strategies
Lovelock 2018[32]	Non comparative study
Lovelock 2018[33]	Literature review
Low 2016[34]	Not a comparison of monitoring programs
Luzzi 2018[35]	Not a comparison of monitoring programs
Malchau 2008[36]	Literature review
Mannien 2006[37]	Not a comparison of monitoring programs
Marsh 2014[38]	Incorrect comparison
Matharu 2018[39]	Literature review
McGrory 1997[40]	Not a comparison of monitoring programs

Study	Exclusion reason
McNeish 2007[41]	Non comparative study
Meding 2013[42]	Risk factor study
Murray 1997[43]	Incorrect population
Nogaro 2014[46]	Not a comparison of monitoring programs
Nunez-Nunez 2018[47]	Review of antimicrobial resistance and healthcare-associated infection surveillance across Europe
Park 2016[48]	Not review population
Ritter 2002[49]	Not a primary study or systematic review
Schneeberger 2002[51]	Not a comparison of monitoring programs
Schoch 2017[52]	Not a comparison of monitoring programs
Sethuraman 2000[53]	Assessment of people's preference for in person or telephone surveillance appointments
Shah 2018[54]	Not a comparison of monitoring programs
Smith 2013[55]	Assessment of people's preference for in person or telephone surveillance appointments
Stilling 2010[56]	Not a comparison of monitoring programs
Szots 2016[57]	Not an investigation of long term monitoring
Toogood 2016[58]	Not a comparison of monitoring programs
Troillet 2017[59]	Not a comparison of monitoring programs
Veysi 1998[60]	Survey of current follow-up practice
Walton 2008[61]	Non comparative study
Wood 2011[62]	Inappropriate comparison

I.2 Excluded health economic studies

Study	Exclusion reason
Bolz 2010[7]	This study was assessed as partially applicable with very serious limitations as the intervention effects were taken from a single observational study with a 12 month follow up and applied to a 7 year time horizon.
Walton 2008[61]	This study was assessed as partially applicable with very serious limitations as it relied heavily on assumptions without reasoning

Appendix J: Research recommendations

J.1 Follow-up after shoulder replacement

Research question: What is the optimum time between follow-up appointments for people who have had shoulder replacement, who should lead follow-up and how this should be organised between hospital and community care?

Why this is important:

While hip, knee and shoulder replacements have demonstrated clinical and cost-effectiveness in improving health-related quality of life for people, complications do occur. These can be short-term, such as within the first 30 days after the operation, or longer-term related to infection, joint loosening or revision. Across the UK there is considerable variability in what mechanisms are used to monitor patients who have had these operations. Some hospital trusts may choose to follow patients up from after their operation, and arrange appointments to clinically and radiologically assess them at different intervals. Others may routinely see their patients at 6 weeks after the operation and then not routinely arrange further follow-up appointments. For these patients, community services and primary care are often the first port of call for identifying and managing complications but this is a reactive rather than pro-active approach. This therefore creates an inequality in consultation number, but there is insufficient evidence to ascertain whether this translates in better detection of complications and improved overall management. Given this variability, better understanding which follow-up approach should be adopted would be useful.

PICO question	Population: People who have undergone shoulder replacement surgery. Intervention(s): Formal follow-up monitoring programme that includes different time points (e.g. 6 months, 1 year, 2 years and 5 years) where individuals are followed up by a health professional to assess for on-going health needs, joint complications and strategies to optimise the health of the joint replacement. This may include clinical or radiological investigation. This may be in a face-to-face consultation, in primary or secondary care, or using technology to permit remote consultations. Comparison: No routine follow-up with a healthcare professional following the standard 6 post-operative week follow-up appointment. Outcome(s): Complications; revision procedures; pain; function; health-related quality of life; health economic measures (direct and indirect costs).
Study design	[It should also specify the most appropriate study design to address the proposed question(s). Primary research or secondary research (for example, systematic reviews) can be recommended.] Pragmatic, multicentre, randomised controlled clinical trial including health economic and process evaluation methodologies.
Other details	Detail any of the following if they are appropriate: relevance to existing national priorities, importance to patients or the population, relevance to NICE guidance.

	This is an important research question given the paucity of literature on this question, and wide variability in the current UK provision of monitoring people following primary hip, knee and shoulder replacement.