Getting sustainable, person-centred musculoskeletal health intelligence from primary care electronic health record linkage and modelling: the PRELIM initiative

Study Protocol

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Chief Investigator: Dr Ross Wilkie

Signature: ____ _____ Date: _____28/11/2017_____

Sponsor Representative: Clark Crawford

Signature: _____ Date: _____

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KEY STUDY CONTACTS

Chief/ Principal Investigator	Dr Ross Wilkie, Senior Lecturer in Public Health & Epidemiology, Arthritis Research UK Primary Care Centre, Research Institute for Primary Care & Health Sciences, Keele University, Keele, Staffordshire, ST5 5BG. Tel: 01782 734845; Email: r.wilkie@keele.ac.uk; Fax: 01782 733911
Co-Investigators	Prof George Peat, Professor of Clinical Epidemiology, Arthritis Research UK Primary Care Centre, Research Institute for Primary Care & Health Sciences, Keele University, Keele, Staffordshire, ST5 5BG. Tel: 01782 733906 (734707); Email: g.m.peat@keele.ac.uk; Fax: 01782 733911 Prof Kelvin Jordan, Professor of Biostatistics, Arthritis Research UK Primary Care Centre, Research Institute for Primary Care & Health Sciences, Keele University, Keele, Staffordshire, ST5 5BG. Tel: 01782 733924; Email: k.p.jordan@keele.ac.uk; Fax: 01782 733911 Dr Daniel Prieto-Alhambra, Associate Professor & NIHR Clinician Scientist, Musculoskeletal Pharmaco and Device Epidemiology, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, OX3 7HE. Email: daniel.prietoalhambra@ndorms.ox.ac.uk Prof Alan Silman, Professor of Musculoskeletal Health, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, OX3 7HE. Email: a.silman@ndorms.ox.ac.uk Dr Andrew Judge, Associate Professor & Senior Statistician, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, OX3 7HE. Email: a.judge@ndorms.ox.ac.uk Prof Karen Walker-Bone, Associate Professor in Occupational Rheumatology, Medical Research Council Lifecourse Epidemiology Unit, University of Southampton, University Road, Southampton SO17 1BJ. Email: kwb@mrc.soton.ac.uk Prof Mamas Mamas, Professor of Cardiology, Institute for Science & Technology in Medicine, Keele University, Guy Hilton Research Centre, Thornburrow Drive, Hartshill, Stoke-on-Trent ST4 7QB. Email: m.mamas@keele.ac.uk Prof Kate Dunn, Professor of Epidemiology, Arthritis Research UK Primary Care Centre, Research Institute for Primary Care & Health Sciences, Keele University, Keele, Staffordshire, ST5 5BG. Email: k.m.dunn@keele.ac.uk Dr Clare Jinks, Reader in Applied Health Research, Arthritis Research UK Primary Care Centre, Research Institute for Primary Care & Health Sciences, Keele University, Keele, Staffordshire, ST5 5BG. Email: c.jinks@keele.ac.uk Stephen Blackburn, Research Associate: Patient and Public Involvement, Arthritis Research UK Primary Care Centre, Research Institute for Primary Care & Health Sciences, Keele University, Keele, Staffordshire, ST5 5BG. Email: s.blackburn@keele.ac.uk

	Dr Jo Protheroe, Senior Lecturer in General Practice, Arthritis Research UK Primary Care Centre, Research Institute for Primary Care & Health Sciences, Keele University, Keele, Staffordshire, ST5 5BG. Email: j.protheroe@keele.ac.uk Stephen Dent (lay member)
Statistician	Prof Kelvin Jordan, Professor of Biostatistics, Arthritis Research UK Primary Care Centre, Research Institute for Primary Care & Health Sciences and Keele Clinical Trials Unit, Keele University, Keele, Staffordshire, ST5 5BG. Tel: 01782 733924; Email: k.p.jordan@keele.ac.uk; Fax: 01782 733911
Sponsor	Keele University, Staffordshire, ST5 5BG.
Sponsor Representative	Dr Clark Crawford, Head of Research and Clinical Governance, Directorate of Engagement & Partnerships, IC2, Keele University, ST5 5NH Tel: 01782 733371; Email: research.governance@keele.ac.uk
Clinical Trials Unit	Keele CTU, Keele University, Keele, Staffordshire, ST5 5BG. Email: ctu.operations@keele.ac.uk

ABSTRACT

Better health intelligence is needed for the common musculoskeletal conditions that cause the greatest amount of disability in the United Kingdom (UK). Primary care has a critical role in responding to this challenge and electronic health records (EHR) from this setting are increasingly recognised as an important driver for public health policy, clinical practice, and research. However there is a need to move beyond recorded processes of care to incorporate information on patient health-states, experiences and outcomes like the impact on work, function and quality of life.

We propose to conduct a cross-sectional survey of key patient-reported outcomes and 'psychosocial vital signs' at baseline of adults aged 35 years and over registered with up to 11 general practices. Our focus will be on the most common, disabling musculoskeletal disorders: osteoarthritis, low back pain, neck pain, and other regional musculoskeletal pains (shoulder, knee, hip, hand/wrist, widespread pain). An internal pilot phase will pilot the survey methods in one-two additional general practices. The main survey will then use an adapted "case-cohort" sampling procedure to survey 9000 patients with a recent general practice consultation for a musculoskeletal condition of interest ("musculoskeletal consultation cohorts"), plus a random sample of 9000 adults in the registered practice population. Participants will be given the option of completing the survey by pen-and-paper or online.

Cross-sectional analyses will estimate the occurrence, impact, and healthcare outcomes of adults with musculoskeletal conditions with particular focus on disability, work participation, and quality of life. We will examine the extent of health inequalities in these and in the key social and behavioural risk factors that are believed to determine them.

The findings of this study will be used to inform plans for a national system of musculoskeletal health intelligence that is capable of providing timely, sustainable, relevant key data on musculoskeletal health, disease, risk, and outcomes for the public, healthcare professionals, and policymakers.

BACKGROUND & RATIONALE

Improvements in managing disabling disorders are failing to keep pace with increases in life expectancy leading to an increase in the number of years lived with disability [1]. Musculoskeletal conditions are a major contributor to this trend in population health [2,3]. Globally low back pain is the leading cause of disability [2] and in the United Kingdom (UK) accounts for substantial health care costs [4]. Osteoarthritis is the most common joint condition in adults and the magnitude of the effect on years lived with disability in the population has increased as the population age distribution and the prevalence of obesity have risen [5,6]. The rate of hip and knee replacement operations has also increased markedly in the UK and worldwide and 95% of these are done for osteoarthritis [7,8]. The Global Burden of Disease highlighted other musculoskeletal disorders - these include shoulder disorders and chronic widespread pain [9] - that also have a substantial impact on the amount of people's lives that are spent in persistent pain, unable to do the things they want to do, and generally blighting quality of life. These common musculoskeletal conditions have proven over decades to be stubbornly resistant to treatment and represent one of the greatest challenges to population health and to healthcare services in the 21st century.

Despite such overwhelming evidence of the significance of musculoskeletal disorders to population health, there is a general lack of systematic, ongoing capture of data – particularly with regard to their impact on patients and outcomes of care - to inform public health policy and health service development. Maybe due to the lack of resulting hard outcomes such as death or acute life-threatening events (e.g. acute myocardial infarction or stroke), musculoskeletal health intelligence has lagged behind cancer, cardiovascular, child and maternal health, end of life, and mental health; all of which have established national health intelligence networks co-ordinated by Public Health England. The need for better data on common disabling conditions like back pain and osteoarthritis is recognised by the Chief Medical Officer, Public Health England, and Arthritis Research UK [10-12]. Within the NHS in particular there is a need for this information to evaluate the 'real world', inequitable provision and outcomes of care, and to identify missed opportunities for improved prevention and management. However, existing health indicator frameworks in the UK provide very limited detail on musculoskeletal health and outcomes. Public Health England's Outcome Indicator Framework, for example, contains only hip fracture rates as a musculoskeletal-specific indicator [13]. The long list of indicators covered in NHS Outcomes relies mostly on Hospital Episode Statistics (in-patient admissions) and national government-sponsored surveys (e.g. Labour Force Survey, Health Survey for England, Annual Population Survey) and fail to cover the vast majority of common musculoskeletal disorders. The national GP Patient Survey (GPPS) defines health states by the generic EQ-5D and has only crude classification of musculoskeletal disorders (e.g. 'arthritis or long-term joint problem') [14]. The challenge is how to obtain better information from other existing sustainable sources of information on musculoskeletal health and outcomes. A compelling case can be made for the use of ***primary care electronic health record (EHR) data, and its linkage to patient-reported musculoskeletal-specific health states and outcomes*** to address these information gaps.

Primary care is where 90% of all NHS contacts take place and where people with common musculoskeletal disorders will typically present their problem, receive ongoing management, and gain access to specialist care [15]. Gathering musculoskeletal health intelligence in primary care offers the genuine prospect of highlighting opportunities for more effective prevention and management earlier in the course of these long-term disorders. Examination of such intelligence between populations and over time can highlight inequalities and changing behaviours and practices that can lead to action. General practice registers also provide a comprehensive sampling framework

covering 98% of the population [16], thereby giving the potential to assess musculoskeletal health, risk, and disease in those not accessing healthcare. Mass adoption of electronic health records in primary care presents a unique and still largely under-utilised source of data for health intelligence, documenting patients' journeys through the health care system. It is logical to explore what this ongoing source of data could contribute to sustainable musculoskeletal health intelligence at local, regional, and national level. These data, however, are collected primarily for clinical purposes. The re-use of such data for health intelligence and research presents key challenges and their interrogation and analysis often requires complex methodology [17].

An important limitation in almost all electronic health record information is lack of critical patient-reported information: specifically patient-reported health states (e.g. disability, work loss), phenotypic characteristics (e.g. severely disabling pain), and information on social and behavioural risk factors (e.g. individual socioeconomic status; health literacy) [18,19]. Disability and quality of life are key measures of musculoskeletal health; disability can be prevented and quality of life maintained despite the presence of musculoskeletal conditions [20]. Disability-free life expectancy is a population health indicator that examines whether gains in life expectancy are years of healthy or unhealthy life and is increasingly recognised as a measure of musculoskeletal health [5]. Work is a key outcome for working-age adults and although primary care data is improving via recording of fit-notes, self-reported information on work loss is required to estimate its extent and evaluate the capacity for extensions to working life. Patient report can also describe the quality of musculoskeletal care in the absence of adequate record-based indicators [21-23]. Surveying primary care consulters and the registered practice population and linking these patient-reported data to the electronic health record is a previously under explored and efficient and powerful approach to creating richer information for the monitoring of musculoskeletal health and care. Establishing this approach would move information provision beyond simple diagnostic labels and processes of care to directly assessing the impact of musculoskeletal conditions, patient-centred outcomes of healthcare, and the multiple determinants of these.

Future sustainable collection of patient-reported information must look to online survey methods as a more efficient mode of data collection than conventional pen-and-paper [24]. Rapidly increasing access to Web (86% of UK adults [25]; including 50% of adults aged 55-64 years with smartphones [26]) means that internet coverage is becoming less of a concern. However, the representativeness of (often low) online survey response and the adaptation of questionnaires for mobile phone/tablet completion are still major challenges. Given uncertainty in these areas, an expert review from the National Centre for Research Methods currently recommends retaining a mixed-mode approach in which those unable or unwilling to complete online surveys are offered conventional pen-and-paper self-complete alternatives [24]. This mixed-mode approach affords both the reassurance of conventional methods but also the opportunity to critically evaluate patterns of uptake of the online survey option and the data quality arising from such an approach. Conducting such surveys within the registered practice population offers the added, unique advantage of having available anonymised primary care electronic health record data on the whole population (including non-respondents) enabling a powerful means of evaluating and correcting for response bias. We feel that the application and robust evaluation of this approach provides the most appropriate means of informing the future transition to a fully online system of obtaining timely, valid patient-reported measures from representative samples of patients for musculoskeletal health intelligence.

Better health intelligence is needed for the common musculoskeletal conditions that cause the greatest amount of disability in the United Kingdom. The use of electronic health record data has been described as the 'next frontier' in chronic disease surveillance [27]. Primary care electronic

health records, with linked patient survey data, provide a powerful, sustainable, but still challenging source of information. This proposal from a collaborative research team of experienced researchers, drawn from across Arthritis Research UK's Centres of Excellence and with expertise in the relevant areas, builds on a number of the charity's initiatives and investments: (1) the Musculoskeletal Health Questionnaire (MSK-HQ) [28] whose development has been supported by Arthritis Research UK and is now being promoted by NHS England as its standard patient-reported outcome measure - we will include this as a core measure in our linked patients survey and (2) Arthritis Research UK Indicators Advisory Group.

AIMS AND PURPOSE

The **aim** of this study is to provide a detailed description of musculoskeletal health (including MSK-HQ scores, healthy work life expectancy, disability), key comorbidity (e.g. cardiovascular risk and mental health) and care among consulters and the general population within one geographical area by linking a musculoskeletal-focused patient survey to local, high-quality, primary care EHR data using robust epidemiological approaches

The **purpose** is to contribute to a system of musculoskeletal health intelligence in the UK population that provides useful, timely, sustainable, trustworthy evidence for policymakers, practitioners, and the public

PLAN OF INVESTIGATION

Overview

We propose to conduct a cross-sectional survey of key patient-reported outcomes and 'psychosocial vital signs' at baseline of adults aged 35 years and over registered with up to 11 practices belonging to North Staffordshire CCG and Stoke-on-Trent CCG and who have contributed to the Consultations in Primary Care Archive (CiPCA) since 2000. Our focus will be on the most common, disabling musculoskeletal disorders: osteoarthritis, low back pain, neck pain, and other regional musculoskeletal pains (shoulder, knee, hip, hand/wrist, widespread pain). The survey will use an adapted "case-cohort" sampling procedure to survey patients with a recent general practice consultation for a musculoskeletal condition of interest ("musculoskeletal consultation cohorts"), plus a random sample of the registered practice population.

The Consultations in Primary Care Archive (CiPCA) is an electronic health record database containing anonymised routinely recorded, regularly audited, high-quality information including reasons or consultation prescriptions, sickness certification, referrals, investigations and neighbourhood deprivation from 12 general practices in Staffordshire Moorlands, Stoke-on-Trent, and Newcastle-under-Lyme dating back to the year 2000, with an annual registered population of over 100,000. Existing ethical approval allows us to download the anonymised medical record information from these general practices for research use. 30 peer-reviewed publications have used the CiPCA database.

Project timeline

0-5 months (Jan-May 2017): Appoint members to Project Steering Committee; PPIE to finalise study survey and documentation; Development and testing of Web-based survey platform; Design and test mailing and data entry databases; HRA approvals; Internal pilot

6-12 months (Jun-Dec 2017): HRA approvals (main survey – if applicable); Main survey; Data entry, cleaning, linkage to medical records and previous survey results

13-36 months (Jan 2018-Dec 2019): Data Analysis and dissemination

1.1. Materials and methods

The project proposal involves a cross-sectional survey with linkage (with patient consent) to the high-quality primary care electronic health records from practices that contribute to CiPCA.

Design:

Cross-sectional survey (pen-and-paper and online data collection) with responses linked (with consent) to primary care EHR.

Participants:

The survey will use an adapted "case-cohort" sampling procedure to survey patients with a recent general practice consultation for a musculoskeletal condition of interest ("musculoskeletal consultation cohorts"), plus a random sample of the registered practice population.

Musculoskeletal consultation cohorts: We will invite to participate all adults on the sampling frame with a recorded consultation in the previous twelve months in their primary care records for osteoarthritis (OA) or a musculoskeletal problem in one of the following body regions: low back, neck, shoulder, knee, hip, hand / wrist. Definitions derived through consensus in previous studies at Keele will be used to identify adults consulting for these musculoskeletal conditions. The definitions are based on Read codes which are used to record morbidity within the CiPCA practices. Adults can be eligible for more than one musculoskeletal cohort. Although not specifically sampled, we will also, for analysis, identify within these musculoskeletal cohorts those who fulfil the definition of consultation-based chronic widespread pain, developed and tested within the Keele Primary Care Centre, which is based on regular consultation for musculoskeletal conditions in different body regions over a 5 year period.

Random sample of registered population: Common musculoskeletal disorders are not like cancer or acute myocardial infarction in that a substantial number of people suffer without accessing formal healthcare services and the performance of primary healthcare services should be evaluated in terms of its provision to the population as a whole. This includes, for example, issues of poor access and disillusionment with care from those non-consulters with severe musculoskeletal problems which we have previously documented. An efficient approach to sampling such individuals and also obtaining a fair comparison for understanding the health of musculoskeletal consulters relative to the population is to randomly sample one sub-cohort from the entire sampling frame. This sub-cohort will, therefore, be representative of all adults fulfilling the age and registration criteria at the practices and will include members of the musculoskeletal cohorts defined above. This sub-cohort will act as the comparison group for all of the musculoskeletal cohorts. The sub-cohort sample will be of equal size to the total number in the seven musculoskeletal cohorts.

Eligibility criteria:

Inclusion criteria:

- Adults aged 35 years and over
- Recorded general practice consultation for osteoarthritis or regional musculoskeletal pain complaint (low back pain, neck pain, shoulder, knee, hip, hand / wrist) in the previous twelve months **OR** currently registered with the practice
- Continuously registered at the practice for a minimum of 10 years prior to survey

Exclusion criteria:

- Known inflammatory disease, spondyloarthropathy, crystal arthropathy (musculoskeletal consultation cohorts only)
- Judged on GP screen to be unsuitable for survey due to severe illness, severe learning difficulties, recent diagnosis of terminal illness, major psychological disorder
- Previously stated they do not wish their medical record data to be used for research
- Unable to read/understand English

Notification of general practices:

Each of the general practices will be invited to participate in writing, via email and/or practice visits. Each participating practice will be sent a letter summarising the project together with a practice pack containing a copy of the study protocol, letters of approval, and study documentation. GP practice consent to participate will be formalised through HRA standard agreements.

***Survey design and administration*:**

We will adopt a number of strategies in the design stage suggested to help minimise the threats to validity of the general national trend in declining response rates and selective nonresponse: (i) involve patients and members of the public from our Research Users Group (RUG) in finalising the survey and study documentation; (ii) undertake pre- and pilot testing; (iii) offer the option of both paper and web-based survey completion; (iv) offer a telephone number for questions about the survey.

Pre-testing and piloting:

We will pre-test the survey, study documentation, and online platform with members of our Research Users Group.

To ensure that the procedures for the survey operate as planned we will conduct a full internal pilot (i.e. following all study procedures and we will expect to incorporate the data from respondents with those obtained from the main survey) in 1-2 practices (full details below). Any necessary amendments prior to the main study will be made and the Research Ethics Committee and HRA will be notified.

Data collection:

The survey will be completed using pen-and-paper, with the option of completing the survey online at the second stage, hosted on a dedicated website on Keele University's secure server and accessed by participants using a unique login and password provided in the invitation letter.

For the survey, we will use a three-stage mailing procedure:

- Stage 1: Patients will be sent a Study Pack including a Survey and Participant Information Sheet together with an Invitation Letter from their General Practice inviting them to take part in the study and a prepaid envelope to return the survey. All patients will be given the contact telephone number of a researcher working on the project who will give any other information about the project if needed. Potential participants will be identified by a Read code search of the GP clinical system which will be performed in the GP Practice(s) by members of the GP practice(s) or members of the research team (NIHR CRN West Midlands staff) who hold NHS England honorary research contracts. The mailout for this survey will be performed by Docmail. Data from the clinical system search will be emailed from the GP Practice to Docmail via NHS.net to NHS.net mail to facilitate this mailout. Docmail is a standards-compliant hybrid mail service, providing document management and ISO 27001 secure mailings.

- Stage 2: Non-responders at 2 weeks will be sent a repeat study pack, as in stage 1. In addition participants will be given the option of completing their survey either using pen and paper or online. The Invitation Letter will include information on how to complete the Survey online (i.e. the website address and a unique login ID and password).

- Stage 3: Non-responders at 4 weeks will be sent a Study Pack as in stage 1 which will include a Minimum Data Collection survey in place of the full survey. Participants will be asked to complete the survey using pen and paper and return in the prepaid envelope.

Non responders after 6 weeks will be assumed to have declined participation and will not be contacted again. Patients who indicate they do not wish to take part in the study in the initial recruitment stage will have this recorded in the database and will not receive any follow-up mailings.

Return of completed surveys will be taken as implicit consent for the use of the survey data they provide. In addition, participants who complete the survey will be asked to provide informed consent for (i) linkage of their responses to their medical record; (ii) linkage of their responses to responses they provided in previous surveys (see "Linkage to prior survey responses" below). Those who complete the survey using the paper survey can provide written consent (i.e. by signing and entering their name and address on a detachable consent form on the final page of survey). Those who complete the survey online can provide consent by indicating their willingness by ticking a "yes" box for each request. Each participant's unique login ID and password will be randomly generated and will include upper and lower case letters and numbers to prevent unauthorised consent. If a participant attempts to log in 10 times without success, they will be locked out to prevent unauthorised access. The participant will then be asked to complete the survey on paper.

Survey content:

The content of the survey will include measures and items that have previously undergone extensive testing, validation, and application and, where possible, offer opportunities for internal or external comparison (e.g. with data from NHS Health Checks, NICE QOF indicators, GP Patient Survey, Health Survey for England). The content of the survey will contain validated measures:

- 15-item Arthritis Research UK MSK-HQ [28]
- General health status (EQ-5D) [29], and subjective health states - pain frequency and intensity [30], sleep quality [31], physical function/limitation [32], anxiety and depression [33], social participation [34]
- Work loss, productivity and satisfaction [35]
- Core demographic, psychosocial and behavioural factors: age, gender, employment status, marital status, educational attainment, occupational class, perceived adequacy of income, area-level deprivation score from postcode [36], tobacco and alcohol use, physical activity, height and weight, caregiving duties, resilience [37]
- Brief measure of health literacy [38]; items required for calculating cardiovascular risk scores [39, 40], and to identify use of over the counter medication and health care for pain

The Minimum Data Collection survey will include;

- 15-item Arthritis Research UK MSK-HQ [28], EQ-5D [29], 2 items on pain intensity [30] and 3 demographic items (age, gender and employment status).

1.2. Data entry, cleaning, storage

Data entry. Each participant will have a unique study ID. The paper version of the survey will be designed in TeleForm which will allow data to be scanned into a database specifically designed for this study. Prior to data entry, this database will be tested using a set of dummy data. Logging of response and consent in the study database will be performed by the Study Administrator. Data from participants completing their survey online will be entered directly into the database by the participant. Personal data received on the consent form will be held separately from the data entry databases. The data is to be housed with the Keele Clinical Trials Unit (CTU) secure virtual network, which requires two factor authentication in order to access it. The network also holds a level 1 in the government backed scheme, Cyber Essentials. Roles and permissions within the database prevent unauthorised user access. Prior to data cleaning, the TeleForm data will be held on a Keele University server with controlled access. All databases will conform to current data protection laws.

Data cleaning. All scanned data, from the paper version of the survey, is machine read within the TeleForm software and any anomalies detected by the software require real-time manual verification. Following this first stage of data cleaning, data from the paper and online surveys will be amalgamated. All verified data is then cleaned, under the supervision of the study statistician.

Data storage. Surveys completed by pen-and-paper will be pseudonymously stored by the Research Institute for Primary Care and Health Sciences for a minimum of 5 years in line with Keele CTU standard operating procedures. Data from surveys completed online will to be housed with the Keele Clinical Trials Unit (CTU) secure virtual network. Completed consent forms will be securely stored separate to research data.

Linkages to primary care EHR and prior survey responses:

For respondents consenting to linkage, we will link survey information to their primary care medical records within a standalone study database, using a unique study ID as the identifier. Records will

initially be collated from date of first registration or year 2000 (whichever is earliest) to one year after survey response. Full general practice medical records of consenting participants will be accessed and securely downloaded to obtain information on consultations, prescriptions and associated aspects in the medical record, for the duration of the study requirements. CiPCA will remain a separate, anonymised medical record only database for the entire practice populations and will not contain study ID, self-reported information or any indicator of response to survey. In this way we can compare responders to the survey to the total practice populations to assess generalisability without concern of identifying non-responders or non-consenters in CiPCA. We will adapt other publicly accessible code lists or use similar GP consensus approaches to identifying morbidities from the medical records for which we do not have code lists. Similar approaches will be used to identify other information from the records (e.g. prescriptions and sickness certification).

In 2001-2003, CiPCA practices participated in two surveys of their registered adult population aged ≥50 years containing key measures shared with the current survey. Respondents to the current survey will be asked for their consent to link their responses to earlier surveys, enabling potential for evaluation of long-term changes in health and its relationship to care received during this time.

If a participant withdraws consent for linkage, then no further information will be gathered. However, data gathered up to the point of withdrawal will be included in the study analyses, unless the participant explicitly states that they do not wish this to happen.

Patient and Public Involvement and Engagement (PPIE):

PPIE occurs in this application at all levels, from design (Research Users Group), through to delivery and dissemination, helping to ensure the relevance of the study to patients, researchers, health service planners and practitioners. Our experienced primary care Research Users Group (RUG), formed in 2006, has 75 RUG members in over 67 projects in all stages of research and covering a wide range of musculoskeletal conditions. Our Arthritis Research UK Primary Care Centre-of-Excellence grants provide funding to underpin infrastructure costs of our PPIE activity in research. RUG members are supported by a PPI Coordinator and Support Worker.

Our RUG has had a significant effect on increasing the impact of our research output in a way that supports rapid translation and implementation. The Research Institute is committed to involving patients and the public in its research, using the INVOLVE framework as the starting point for how we structure and implement PPIE. For this proposed body of research we have actively listened to users' experiences of primary health care for musculoskeletal problems through qualitative interviews in previous studies and RUG meetings. We have convened two dedicated workshops with RUG members - including patients with osteoarthritis and spinal pain - to identify their perspectives on the use of linked anonymised data for this research. The participants felt use of health care data without explicit consent was justified conditional on adequate anonymisation, confidentiality and data security procedures being in place. They also strongly felt that publishing accurate information on trends and variation in musculoskeletal disorders, their management and outcome would have tangible patient benefit. Use of this information would be maximised by engaging those who could act on the information. These comments and suggestions have fed directly into the proposed project. Dr Steven Blackburn, research associate and operational manager of patient and public involvement and engagement in Keele CTU, and Stephen Dent, a RUG member who has ankylosing spondylitis and osteoarthritis, are co-investigators and have been instrumental in developing this project. We will organise regular workshops with our RUG, facilitated by co-applicants Blackburn and Dent, to discuss study objectives, recruitment and data collection procedures, and ask for active involvement in the design of study materials (e.g. surveys, letters to participants, consent forms). Additional RUG

members will also be involved in the management of the research (through membership of the Steering Group) to ensure that the priorities for patients are addressed.

Planned recruitment rate and sample size calculation (based on up to 11 practices):

Our sample size estimates are based on analysis of our CiPCA database and our previous estimates of consultation prevalence for musculoskeletal conditions. Analysis of CiPCA suggests that 73% of adults aged 35 and over will have complete registration for 10 years and that 24% of people in the musculoskeletal cohorts will be in more than one of these cohorts. The estimated number to be surveyed is 14,600. This will encompass 8,200 people in one or more of the musculoskeletal cohorts and 8,200 people in the randomly selected sub-cohort (of which 1,800 will also be in a musculoskeletal cohort). Assuming 40% response and consent to record review, 3,300 people in total from the musculoskeletal cohorts will respond, as will 3,300 in the sub-cohort. With respect to each of the musculoskeletal cohorts, and based on a 40% response rate for each, the anticipated numbers of respondents are: OA (n=560), low back pain/disorders (n=1100), neck pain/disorders (n=440), shoulder pain/disorders (n=530), knee pain/disorders (n=820), hip pain/disorders (n=310), hand/wrist pain/disorders (n=480). Based on previous estimates we anticipate around 640 people fulfilling our definition of consultation-based chronic widespread pain will be included in the responders.

The sample size is based on the total eligible population within the practices. However, as a guide, based on an estimated prevalence of a health indicator such as poor sleep quality of 50%, the size of the smallest responder group (hip pain, n=310) will give a margin of error of 6% in the observed prevalence (this level of error will be smaller for a higher or lower prevalence), or detect an odds ratio of 1.4 (significance level 5%, power 80%) in comparison to the larger random sub-cohort.

Analysis:

Analyses of the self-reported patient measures linked to health care data will use the standalone study database. Robust variance estimators or generalised linear mixed models will be used in all multivariable analyses to account for clustering of patients within practices.

Response rates and sample disposition will be reported in accordance with recommended standards. Selective non-response (based on age, gender and deprivation score) will be evaluated and adjusted for using established approaches and techniques applied in our previous studies.

We will determine population profiles of pain intensity, disability (extent of limitation and disability free life expectancy), anxiety, depression, sleep quality and work participation among respondents within each musculoskeletal cohort (including those fulfilling the chronic widespread pain definition), and the random subcohort, using summary measures (for example, percentage, mean (SD)). Weighting will be used to take into account any selective non-response by age, gender, and practice. Multiple imputation will be used if there is missing data in respondents on the health profile indicators. We will compare the health profiles between the different musculoskeletal cohorts, and to the random subcohort, using logistic, linear, or negative binomial regression models as appropriate, adjusting for age and gender.

Healthy Work Life Expectancy (HWLE) is a population health indicator that indicates the average number of years that people within a particular sample can remain healthy and in work. HWLE will be calculated by combining data on health and employment status to provide an estimate of the

number of years, between the ages of 40 to 70 years, that an individual can be working and healthy. Regression modelling will be used to identify the association between decreasing years in health and work and socio-demographic, workplace, health and healthcare factors.

Within the musculoskeletal cohorts, we will determine inequalities in these health profiles by levels of health literacy, individual and neighbourhood measures of deprivation and occupational class, adjusting for age, gender, and recorded health care use and management (time since last consultation, time since first recorded diagnosis, frequency of musculoskeletal consultation and recorded pharmacological and non-pharmacological management in the last 12 months), again using appropriate regression models. As our musculoskeletal cohorts will all have consulted within the preceding 12 months (plus time to response), we will use the same models to derive an estimate of the impact of primary care consultation by comparing levels of symptom severity and disability by time since last consultation in the musculoskeletal cohorts.

We will assess differences between responders who used the online survey to those who used pen and paper on socio-demographic characteristics, pain intensity and disability, and health care use. We will also compare prevalence of health care use and management of respondents, stratified by mode of response, to patients fulfilling the same inclusion and exclusion criteria within the anonymised CiPCA database in order to assess generalisability of our respondents, given that the CiPCA registered population represents the whole population from which the respondents are drawn.

Pilot study

The pilot study will be conducted to assess the potential response rate and to test the practical aspects of administering the survey, such as the availability and organisation of resources, sample preparation (acquisition of sample names), mailing preparation (Docmail), logging of returned surveys and data processing.

The practical administration of the survey will follow that described in section 1.1.

Sample: The survey will be sent to all registered adults aged 25 years and over, drawn from the age-sex register of two general practices. Once the sample is drawn, GPs from the practice will screen mailing lists for patients who meet exclusion criteria (i.e. an inability to complete the survey due to an inability to read/ understand English, have learning difficulties or psychological disorders, severe or terminal illness or have previously expressed a wish not to participate in any research projects involving their general practice).

Analysis: Overall response rate and completion rates for individual instruments and items will be calculated as proportions (%) and using American Association of Public Opinion Research standard definitions [41].

ETHICAL CONSIDERATIONS

The survey questions do not cover sensitive topics and we do not anticipate any distress arising from completion of the survey.

Participants' personal data will only be accessible by authorised members of the research team during data collection phase of the trial. Personal data will only be received by the research team following consent by the study participant and will be held separately to research data. All trial databases and participant information are housed in the CTU Secure Network, which is a secure virtual network requiring Two Factor Authentication in order to access the data stored within there.

Roles and permissions are applied to users within the network as well as within an application to restrict what data a user can access and operations they can perform. The CTU Secure Network has been independently audited and achieved level one of the Government backed Cyber Essentials Scheme. Once data collection has been completed, all data will be maintained in such a form that they cannot be linked with identifiable participants and will be anonymised in the reports and for archival deposit.

There are secure physical storage arrangements for the hard copy at the Keele CTU within lockable filing cabinets. Completed consent forms will be securely stored separate to research data. In addition any hard copy research data that has been printed for checking will be destroyed by shredding. Surveys completed by pen-and-paper will be stored without names and addresses for at least 5 years in accordance with Keele CTU standard operating procedures.

Response rates to population surveys have been declining over time. We have included several evidence-based strategies to improve response rates to postal and electronic surveys [42]: keeping the questionnaire as brief as possible (and adding a much-shortened version for Minimum Data Collection); highlighting University involvement; personalising cover letters; using posters in the practice to pre-notify the registered population of the imminent mailout; providing an update on response through study website; removing the word 'survey' from the title; posting results from the survey as soon as these are available. In addition we have included a conditional non-monetary incentive indicating that we will donate £200 to a local charity (Alice Charity: registered charity no. 1148385) for every 1000 surveys returned.

PROJECT OVERSIGHT

We will convene a Project Steering Committee and invite lay representation and senior representatives of relevant stakeholders.

DISSEMINATION AND IMPACT

Our success in disseminating research findings and achieving impact is underpinned by a systematic approach to developing research that can make a real difference to patients, healthcare providers and policy makers, coupled with a strategic approach to securing collaborations and partnerships which can support rapid roll-out and translation of the research findings. Dissemination is supported by the Primary Care Consortium Board where outputs of high quality research are disseminated to key stakeholders. The applicants, with PPIE involvement, will produce short reports on progress for Midlands Medicine. At a local level, we will produce regular updates via Clinical Commissioning Groups' (CCGs) newsletters, and through update meetings with R&D leads to influence local quality improvement and provide support for identifying outputs most relevant to the health needs of the local community. Educational slide sets will be prepared and be available for the Royal Colleges, professional bodies and medical charities. Additional knowledge mobilisation activities will be undertaken within the Research Institute's Impact Strategy in order to facilitate uptake by local services. We will seek advice from our PPIE groups to inform the dissemination plan to the public. In addition to posters reporting summary findings in participating practices we will host annual public dissemination events at Keele. Findings will be periodically posted on our study website and through social media using our established organisational Twitter account and blog.

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Appendix 1: *Study flowchart*

Pilot study of adults aged ≥ 25 years registered with one-two general practices
(testing administrative process of cross sectional survey)

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Cross-sectional survey (N=14,600) of adults aged ≥ 35 years with linked medical record review and data modelling

Identification of Patients
A READ code search will be undertaken by NIHR CRN WM on behalf of the GP practice for consultations in the previous twelve months (N=8,200) for:-

- osteoarthritis (OA)
- or a musculoskeletal problem in one of the following body regions:-
  - low back; neck; shoulder; knee; hip; hand/wrist

sub-cohort (8,200 of which 1,800 will also be in the MSK cohort) to act as the comparison group for all of the MSK cohorts (equal size to the total number in the 7 MSK cohorts)

All patients must have been registered in one of the up to 11 participating General Practice for at least 10 years

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Patient list screened for exclusions by GP to exclude:-

- those unable to complete surveys due to severe or terminal illness
- have severe learning difficulties or psychological disorder
- unable to read/understand English
- previously stated they do not wish their medical record data to be used for research

↓

Approximately 14,600 patients mailed a study pack, via Docmail, including a:-

- Letter of invitation (on GP letter headed paper)
- Participant Information Sheet
- Survey (for self-completion) including a Consent Form (seeking consent for Medical Record Review; Linkage to previous survey data (if applicable))
- Pre-paid addressed envelope

↓

Non-responders will receive a reminder study pack as above after two weeks with option of pen and paper or online (electronic) completion

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Two weeks after the reminder pack, non-responders will be sent a repeat study pack as above but containing a minimum data collection survey in place of the full survey

↓

Data Entry
(estimated 5,840 completed surveys from consented participants will be entered onto a secure database either by scanning of survey or online data entry by participant)

Non-responders after six weeks will not be contacted again

Medical Record Review in patients who provided Informed Consent for this review

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Data Analysis & modelling (cross-sectional and longitudinal analysis)

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Writing & Dissemination