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Use of eHealth technologies to enable the implementation of musculoskeletal Models of Care: Evidence and practice

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A B S T R A C T

Musculoskeletal (MSK) conditions are the second leading cause of morbidity-related burden of disease globally. EHealth is a potentially critical factor that enables the implementation of accessible, sustainable and more integrated MSK models of care (MoCs). MoCs serve as a vehicle to drive evidence into policy and practice through changes at a health system, clinician and patient level. The use of eHealth to implement MoCs is intuitive, given the capacity to scale technologies to deliver system and economic efficiencies, to contribute to sustainability, to adapt to low-resource settings and to mitigate access and care disparities. We follow a practice-oriented approach to describing the 'what' and 'how' to harness eHealth in the implementation of MSK MoCs. We focus on the practical application of eHealth technologies across care settings to those MSK conditions contributing most substantially to the burden of disease, including osteoarthritis and inflammatory arthritis, skeletal fragility-associated conditions and persistent MSK pain.

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The role of eHealth in enabling the implementation of musculoskeletal models of care

Musculoskeletal (MSK) conditions are the second leading cause of morbidity-related global burden of disease [1]. In parallel with the current and rapidly escalating burden, significant 'know–do' gaps [2] remain that limit the potential for improving system efficiencies and patient outcomes. Innovative approaches to care are needed, requiring a coordinated whole-of-sector response, and one which is underpinned by evidence-informed health policy [3]. In this context, models of care (MoCs) serve as a vehicle to drive evidence into health policy and guide practice through changes in service delivery systems and clinician behaviour [4]. MoCs describe *how to* operationalise evidence-based guidelines for MSK conditions and thereby support implementation by clinical teams and their health systems. Implementation of MoCs requires a multi-level change: at the macro level (health systems), at the meso level (service delivery) and at the micro level (clinician and patient behaviours). We have recently extensively reviewed the evidence for MoC application to MSK health [3].

EHealth is one of the potentially critical factors that enable the implementation of MoCs thereby levering accessible, sustainable and more integrated contemporary MSK care [4]. EHealth can be broadly defined as a variety of information and communication tools and technologies used in the delivery of health services, or to support patients' self-management. Examples include, but are not limited to, electronic medical records (EMRs), healthcare information systems, telehealth, online clinical decision support tools, mobile health (mHealth) and consumer health informatics. The use of eHealth to enable the implementation of MoCs is intuitive, given the capacity to scale technologies, deliver system and economic efficiencies, contribute to sustainability and adapt to low-resource settings and mitigate access and care disparities [5]. High- and upper middle-income countries are generally more advanced in their eHealth development than lower middle- and low-income countries [5]. However, within the next decade, widely available digital technologies allowing people to connect, communicate and self-track through mobile devices, self-tracking tools, apps and social media will be ubiquitous [6].

In this chapter, rather than providing a systematic review of the role of eHealth in the prevention and management of MSK diseases, we follow a practice and health service-oriented approach to describing the 'what' and 'how' to harness eHealth technologies to facilitate the implementation of MSK MoCs. The use of eHealth will be described at a health system (macro) level, health service delivery (meso) level and the clinical and patient (micro) level. Using working examples, we focus on the practical application of eHealth technologies to those MSK conditions contributing most substantially to the burden of disease, including osteoarthritis (OA) and inflammatory arthritis, skeletal fragility-associated conditions and persistent MSK pain.

EHealth as an implementation enabler for arthritis MoCs

Digital media are gaining popularity in healthcare, because they support creative, inexpensive and flexible ways to provide personalized information and feedback for arthritis care. For MSK care, tailoring of person-centred information is important for supporting self-management and positive behaviour change. Using display platforms that vary from large screen displays to small mobile devices, digital media that comprise multi-media elements based on graphics, animations, simulation and gaming principles can deliver tailored messages and functions to engage users [7]. These applications can be used to communicate experiences, share information and engage with others, offering new tools for designing innovative interventions and empowering patients to actively engage in co-care.

Interactive health communication applications are computer-based information programs that aim to provide health information plus social support, decision support and behaviour change support [8]. Examples include Web-based interventions and online patient decision aids. A Cochrane systematic review of 24 randomised controlled trials (RCTs) concluded that these applications have a moderately positive effect on the patient's knowledge, and modest effect on the perceived social support, clinical outcomes and behavioural outcomes (e.g. being physically active and decreasing caloric intake) [8]. In addition, there was a positive trend in self-efficacy. We present examples of using eHealth tools to implement MoCs and the components of care for arthritis.

EHealth at a systems level for arthritis care

Central intake systems

Central intake systems, introduced in the United Kingdom [9], involve placing all referred patients in a waiting list, with subsequent triaging to the most appropriate healthcare provider or service based on their need and disease severity [10]. Patients are coded and tracked through the system to ensure that they receive the right care. This model has been adopted for the management of OA and inflammatory arthritis. A case study, involving document reviews and interviews with clinic managers and healthcare providers in Alberta, Canada, recommends the use of EMRs with an e-referral system to streamline the process [10]. The latter ensures that all relevant data are obtained before a referral is initiated, thereby minimizing delays due to incomplete referrals. Barber et al. [11] have recently developed key performance indicators to evaluate the ability of central intake systems to address key dimensions of quality of care, including appropriateness, accessibility, acceptability, effectiveness and efficiency [12]. Future research using these performance indicators will provide further insight into the effectiveness of this eHealth-enabled MoC. In this context, the use of effectiveness implementation hybrid designs that combine elements of both clinical effectiveness and implementation research to enhance public health impact may be preferable to RCT designs [13]. As the demand for elective joint replacements increases in high-income countries, the use of eHealth-enabled centralised referral systems in public healthcare settings will become increasingly important, to ensure timely access to surgical care and optimise service delivery efficiencies.

EHealth tools for clinicians delivering arthritis care

Workforce capacity building tools

Building health workforce capacity and capability is essential for sustainable implementation of MSK MoCs [14]. In order to address an important workforce capacity limitation in rheumatoid arthritis (RA) care [15] and to implement the Western Australian Inflammatory Arthritis Model of Care [16], the Rheumatoid Arthritis for Physiotherapists e-Learning tool (RAP-eL: http://www.rap-el.com.au/) was developed. RAP-eL is an interactive, innovative and modular Web-based learning resource developed to improve physiotherapists' confidence, likely practice behaviours and ability to manage people with RA, and improve their clinical knowledge in several areas of best-practice RA management. RAP-eL has shown effectiveness in achieving these outcomes and has been effectively implemented in upskilling programs for the current physiotherapy workforce [17] undergraduate physiotherapy in Western Australia and Ireland [18] and medical curricula in Victoria, Australia [19]. Successful development and implementation were levered through a cross sector and cross-discipline partnership model that enhanced engagement, professional body support and dissemination, and finally an expanded large-scale roll-out. Google Analytics™ data for January 2014 to April 2016 indicated 12,000 users from 140 nations.

Other point-of-care eHealth tools: movement and computer vision technologies

Recent advances in movement and computer vision technologies have made real-time mobility and movement monitoring in natural settings feasible (e.g. a patient's performance of home exercise). Such technology can be implemented by clinicians to help lever co-care for patient exercise and activity recommendations that are consistent with the recommendations in MoCs and clinical practice guidelines. This technology allows for provision of real-time feedback on exercise performance in a variety of settings, and on body movement during daily activities. There are two categories of movement sensors: (1) wearables that are based on accelerometer and GPS technologies for whole-body tracking (e.g. Fitbit™) and (2) body segment tracking sensors used in gaming devices (e.g. the Kinect™ sensor). Wearable sensors can measure a person's movement quality and quantity, offering new ways to understand relationships between activity dose and clinical signs, symptoms and joint damage. Moreover, sensors such as Kinect™ can automatically detect and track the human skeleton in its field of view without the need to wear any markers [20].

EHealth to support patients' participation in arthritis care

Web-based self-management for arthritis

Contemporary MoCs for arthritis emphasise the importance of supporting patient self-management using a range of resources [3]. Here, eHealth offers a significant opportunity to support self-management approaches. The Internet Chronic Disease Self-Management Program consists of six weekly online workshops moderated by two trained peer moderators [21]. Individuals also log on at least thrice a week to read the online content and join the bulletin board discussion. A 12-month RCT showed a significant improvement in patients' health distress and participation in stretching and strengthening exercises, compared with the usual care group [21].

Another online self-management program called RAHelp (rahelp.org) was developed by researchers at the University of Missouri. This 10-week Web-based program consisted of self-management modules for patients with RA, a personalized ‘to do’ list, a news feature, a resource library and a journal for tracking the level of pain and stress. An interactive area, the RAHelp Village, offered patients the opportunity to engage in group or individual discussions. Results of an RCT showed that RAHelp improved self-efficacy and quality of life up to 9 months [22]. A subsequent analysis revealed that the burden for administrating the program in the community was low, suggesting that it is feasible to implement more widely [23]. Other flexible platforms that offer personalised self-management support, rather than requiring users to undertake modular training, such as MyJointPain, have also been introduced, with preliminary data suggesting effectiveness in some self-management domains [24].

For young people with juvenile idiopathic arthritis (JIA) and their parents, Stinson and colleagues developed an online program Teens Taking Charge, which consists of 12 online learning modules covering arthritis, treatment, self-management tips, lifestyles and planning for the future [25]. A separate module was developed for parents to address the impact of arthritis and how to prepare their children to take charge in managing their health. This program was developed and evaluated using a sequential, phased approach consisting of program development, usability testing (ease of use, ease of learning, errors and efficiency) and outcome evaluation (satisfaction with content, user interface and functionality of the program) [26]. Usability testing helps to explore what works, what does not and where gaps in information or functionality exist, as these factors may affect the likelihood that a user will implement the recommendations. A pilot study of 46 patients with JIA across four tertiary care centres showed that implementation was feasible (high compliance, acceptability and satisfaction), with significant improvement in outcomes, including participants' arthritis knowledge and pain skills. A full-scale RCT is currently underway.

At present, an international Canadian-Australian RCT has been conducted to examine the effect of implementing an online program, People Getting a Grip on Arthritis for RA, using information communication technologies (i.e. Facebook and e-mails) combined with arthritis healthcare professional support and e-educational pamphlets [27]. This partnership approach to co-implementation involves the Arthritis Society in Canada (giving access to the e-program) and arthritis patient organisations in Canada and Australia being engaged to lever recruitment and dissemination of the eHealth intervention.

Online patient decision aids for arthritis care

Patient decision aids are evidence-based tools designed to help patients choose between two or more management options [28], by helping them to personalize the information about treatment effectiveness, outcomes and the inherent uncertainties of potential benefits versus potential harm. The use of patient decision aids was a response to the shift from traditional authoritative MoCs, in which health professionals make treatment decisions for patients, to shared decision-making [29]. Recently, Li et al. [30,31] have developed an interactive decision aid for patients who consider methotrexate for RA, called the ANSWER (answer.arccanada.org). This eHealth tool was implemented with patients asked to consider two options: (1) use methotrexate as prescribed and (2) ask the doctor to recommend a different medication. The program includes an information module consisting of six animated patient stories illustrating the benefits and side effects of methotrexate, a preference elicitation module guiding the patients to consider the pros and cons of using methotrexate, and a set of health questionnaires. An iterative usability test was conducted with 15 RA patients to ensure smooth navigation and user-friendliness [30], which are important components of effective implementation. A proof-of-concept study found that the ANSWER reduced patients' decisional conflict (i.e. the feeling of uncertainty and being unsupported while making a treatment decision) and improved their methotrexate knowledge. Despite these benefits, challenges related to the implementation of patient decision aids in rheumatology practice have been identified, which include rheumatologists being unfamiliar with patient decision aids and the perception that their use may disturb the clinical workflow [32]. The results indicate a need to develop implementation strategies to support integration of this type of tool in clinical practice.

MHealth applications for arthritis care

Several studies have examined the use of smartphones and mobile devices in delivering behaviour change interventions for chronic diseases including arthritis. Fjeldsoe et al. [33] examined the use of short message service (SMS) for supporting healthy behaviours, including smoking cessation, increased physical activity and participation in chronic disease self-management. They also found that tailored content and interactivity were important features of successful SMS interventions. A second review by Wei et al. [34] concurred that the use of SMS could improve individual's adherence to medication and medical monitoring. However, the integration of smartphones and mobile devices in arthritis service delivery models is at the early stage. Implementation of SMS and e-mail-based interventions will need to address challenges faced by patients and health professionals regarding comfort levels with virtual communication, privacy concerns and additional burdens [35].

Practice Points

- Creative use of eHealth technology has the potential to enhance the delivery of interventions to support arthritis care and patient self-management.
- Usability testing is crucial in the development of eHealth tools to ensure user-friendliness of the intervention.
- Effectiveness of eHealth interventions can be studied together with context-specific implementation barriers and facilitators, including individual characteristics (e.g. clinician and patient's willingness to adopt a new intervention) and practice challenges (e.g. time, workload and organisation), using a hybrid implementation effectiveness study design [13].

EHealth as an implementation enabler for skeletal fragility MoCs

The 2010 Global Burden of Disease Study analysis identified an increasing absolute burden of disease associated with low bone mineral density (BMD) and an increasing proportion of fall-related deaths due to low BMD, particularly in developing countries [36]. East Asia and South Asia were the major contributors to the increase in global burden associated with low BMD [36]. In this context, strategies to optimise skeletal health, prevent fractures and arrest the fracture cascade following incident fractures, are a critical focus of global action, to address not only osteoporosis but also the health sequelae associated with fractures. Harnessing eHealth technologies, in particular mHealth, as an implementation strategy to address skeletal fragility, offers a realistic and sustainable option that is appealing and accessible to citizens, particularly in developing countries, where access to mobile phone technologies is increasing [5]. Examples of how eHealth tools are being used to implement MoCs and their components of care for skeletal health are discussed below.

EHealth at a systems level for skeletal fragility care

E-registries for skeletal fragility care

Population-level surveillance using e-registries to monitor minimal-trauma fracture epidemiology is important for addressing clinical and population health questions related to post-fracture care and health outcomes at a systems level. This is particularly the case for evaluating contemporary MoCs for osteoporosis, such as the Fracture Liaison Service model [3], and prospective evaluations of population-based skeletal health, especially in the context of an ageing global population. EHealth systems that offer standardized, efficient data entry, monitoring and management for end users and collection of both clinical and patient-reported outcomes for all fracture sites are necessary to address such important public health issues. This complexity has been difficult to achieve in a single registry until recently, for example, with the introduction of the Swedish Fracture Registry (SFR) [37]. The overall aim of SFR is to improve Swedish health system outcomes by providing population-based data on fracture management in combination with patient-reported health outcomes. The system therefore lends itself well to supporting evaluation of system-wide MoCs for skeletal health.

Wennergren et al. [37] outline the implementation process of the SFR. All system-level health reforms require champions to agitate for change [38]. In the case of the SFR, local orthopaedic surgeons led the development process, supported by project managers and system developers. A governance structure was established and a central agency undertook responsibility to support the SFR. Data entry is Web-based and designed to be simple and intuitive, such as the use of a mouse-pointer to select the location of a fracture(s) from a digital skeleton image. Local implementation was supported in participating hospitals by site visits from SFR staff, consistent with best practice for implementation of new MoCs [38]. Digital tools are being developed to search hospital records for missing fracture cases to work towards 100% incidence accuracy, while partnership opportunities with other professional groups, such as the Swedish Spine Association, are being explored to include other fracture types.

Telehealth for skeletal fragility care

Systematic review-level evidence highlights the effectiveness of telehealth services for the delivery of therapeutic interventions in patients with chronic conditions who live in rural settings [39]. This application is particularly relevant in nations with large landmasses such as Australia and Canada, where care disparities are commonplace, due to geography and a lack of an appropriately skilled health workforce [40]. Notably, the importance of telehealth for skeletal fragility care is reflected in contemporary osteoporosis care strategies that have been developed for health areas [41,42], although few studies have examined the effectiveness of this digital technology for osteoporosis care. A recent cluster RCT identified that telephone support from a centralised fracture liaison co-ordinator was associated with improved post-fracture care in facilities that did not have resources or capacity to establish on-site fracture liaison coordinators [43]. Quality assurance data also point to the feasibility of delivering multidisciplinary osteoporosis care through telehealth to communities where access to multidisciplinary health professionals is limited [44]. In this latter example, a formal change management process was undertaken to support implementation of the initiative, including:

- Formation of a subcommittee to translate the in-person cross-discipline clinical encounters into a telehealth model of service delivery with consideration of consultation and telehealth technical requirements (e.g. various camera angles).
- Clinician champions were identified to sit on the subcommittee to ensure engagement from other clinical staff.
- Staff interviews were conducted to understand current clinical and administrative practices, and how they could be applied to a telehealth mode.
- Training was provided to clinical and administrative staff.
- Patient e-resources were developed, such as an online introductory video webcast – a component of care normally undertaken in person by a clinical nurse specialist.

Highlighting the importance of articulating technological innovation with health policy [38], this project has been integrated as a cornerstone of the Ontario Osteoporosis Strategy [41], which is fundamental to its sustainability and expansion. Collectively, these data indicate the opportunities that eHealth technologies afford to facilitate the implementation of innovative MoCs for skeletal care and expansion of traditional service delivery models at scale.

EHealth tools for clinicians to deliver skeletal fragility care

Identification of an individual's absolute risk of fracture is critical for the delivery of the right care at the right time. Because BMD alone cannot be reliably used at the patient level to determine fracture risk [45], eHealth tools that enable risk stratification based on clinical factors are of significant clinical value in the management of skeletal fragility.

Online risk calculators for skeletal fragility care

Several online fracture risk calculators (FRCs) are available to clinicians for this purpose. FRAX® is the most widely used fracture risk assessment tool sponsored by the World Health Organization (WHO) (https://www.shef.ac.uk/FRAX/). It combines clinical risk factors with or without BMD data to estimate an individual's absolute 10-year risk of osteoporotic fracture using country-specific normative data [46], which now exist for some 56 countries. The Garvan FRC (http://www.garvan.org.au/promotions/bone-fracture-risk/calculator/) is a similar tool and has comparable predictive validity in women [47]. Further country-specific validations are recommended for both tools, and cognisance of their limitations as stand-alone risk assessment tools. Implementation of FRCs at scale is progressing. For end users, FRAX® is currently available as an online desktop tool, an offline tool or as a smartphone App (all available at http://www.iofbonehealth.org/osteoporosis-musculoskeletal-disorders/osteoporosis/diagnosis/frax-information-and-resources). Furthermore, the National Osteoporosis Foundation and the International Society for Clinical Densitometry now recommend FRAX® evaluation as a component of bone densitometry [48]. Ultimately, these tools could also be used by patients to judge their skeletal fragility risk and prompt them to seek professional review.

Other point-of-care e-tools for skeletal fragility care

Besides FRCs, other point-of-care e-tools have been showed to improve clinician behaviours related to guideline-consistent care for skeletal fragility, such as EMR reminders [49], including tools that require real-time entry of patient-reported data. Systematic review-level evidence suggests that clinical outcomes are optimised with tools that target clinician behaviour and patient behaviours, which include multiple combined components, such as information *with* education [50].

While intuitively useful and supported by systematic review and meta-analysis-level evidence for improving clinician care in prevention practices, ordering of investigations and prescribing in high-income economies [51], clinical e-decision support tools vary widely in effectiveness and capacity for sustainable implementation [52]. A key question, therefore, is what makes a clinical e-tool successful in practice? This question remains largely unanswered and is an important research priority area. For example, a systematic review of clinical e-decision support tools for prescribing was unable to determine features of successful implementation [53], highlighting the need for rigorous implementation research in this area. Common implementation features, whether successful or unsuccessful in implementation outcomes, included:

- Decision support at the time and place of decision-making
- Provision of a recommendation rather than just an assessment
- Automatic provision of decision support as part of clinician workflow
- Integration with other EMR interfaces (e.g. medicines dispensing)
- Convenient locations for the computers (e.g. co-location with clinical assessment rooms).

Furthermore, most of the research in this area appears to be conducted in high-income countries. Transferability to low- and middle-income nations remains an important research question.

EHealth to support patient participation in skeletal fragility care

MHealth applications for skeletal fragility care

In the context of skeletal health MoCs, eHealth enablers for patients most often focus on optimizing nutrition and supporting safe and effective physical activity. MHealth apps offer a convenient tool for patients to participate in positive health behaviours; a key component of bone health and reflected in osteoporosis and bone healthcare strategies and MoCs. For chronic MSK conditions, however, complex messaging is often required [54]. Whether apps supporting health behaviour change (e.g. exercise and nutrition) are developed in a manner that integrate behaviour change science, clinical evidence and clinical experience remain uncertain [54].

The Safe-D app was developed in a participatory research model with the aim of preventing vitamin D deficiency (a key factor in skeletal health) in young women. Safe-D encourages safe ultraviolet (UV) radiation exposure through individualized UV exposure recommendations, messages and UV exposure education [54]. Here, balancing complex messages about the importance of UV exposure for vitamin D synthesis against skin cancer safety was considered important, particularly in countries like Australia, where the incidence of melanoma is extremely high. This was achieved through iterative development phases involving a multidisciplinary team of clinicians, end users, systems researchers and developers and informed by research evidence. Through the process, recommendations for interactive eHealth apps were put forward to maximize implementation success, that is, effectiveness and usability. These recommendations were:

1. Involve a multidisciplinary team in the development process
2. Engage users through managing complex messaging
3. Design for interactivity (i.e. user-friendliness).

Web applications for skeletal fragility care

While the principles of exercise for bone health are well understood, application of these principles in the context of self-management with consideration of an individual's level of skeletal fragility, co-morbidities and fracture history is complex, again requiring complex and individualised messaging. A recent initiative from Osteoporosis Canada, in partnership with the University of Waterloo, sought to address this issue with the Too Fit To Fracture program. The program involved defining safe and appropriate exercise according to fracture risk based on published evidence and expert consensus [55] and translation of evidence and real-world recommendations into user-focussed materials. The same development pathway has also been used for other eHealth applications, such as RA care [17]. The partners developed patient-centred stories and practical examples of exercise programs according to fracture risk, using a series of YouTube clips delivered via the Osteoporosis Canada website (http://www.osteoporosis.ca/osteoporosis-and-you/too-fit-to-fracture/video-series-on-exercise-and-osteoporosis). The initiative was promoted globally in November 2015, where one video per day was posted for the month of November.

Practice Points

- Development of eHealth technologies and their implementation offers an important and sustainable opportunity to improve skeletal fragility care.
- Monitoring the epidemiology of low-trauma fractures with e-registries that measure clinical and patient-reported outcomes is critical for improving health system quality and performance of fracture care.
- Alignment of system improvement eHealth programs for bone health can be maximised when initiatives are aligned to jurisdictional policy and strategy. Such alignment promotes sustainability by facilitating uptake at scale and provision of resources.
- Development of apps to support co-care in skeletal health should involve clinicians and patients and be based on best-practice evidence and guided by contemporary behavioural theories.

EHealth as an implementation enabler for MSK pain MoCs

Management of persistent MSK pain offers great potential for digital health management (social media, mHealth and online interventions) as a component of care by increasing participation, flexibility, autonomy and mobile self-management [6]. In this context, eHealth can be used to facilitate the implementation of MSK pain MoCs at health system, clinician and patient levels.

EHealth at a systems level for the management of persistent pain

One significant opportunity raised with the emergence of eHealth interventions for pain is the potential for the development of formal stepped-care systems of pain management [56,57]. Using this model, all patients with persistent pain are initially referred or provided the opportunity to participate in lower-cost, accessible, Internet-delivered interventions prior to the use of higher-cost and stepped-up intensive face-to-face pain management interventions [57]. This approach provides a significant opportunity, given the high prevalence of persistent pain and the limited resources usually available to specialist face-to-face pain management services [58]. Furthermore, the approach aligns with a face-to-face system-inversion approach recommended in the Western Australian Spinal Pain MoC [59]. This approach involves patients seeking pain care undertaking a group-based knowledge and skills program before seeking specialist pain care. Health and economic benefits were demonstrated using this model in a tertiary pain medicine setting [60], with recent further expansion into primary care. However, much more work is needed to understand how eHealth-delivered interventions might be effectively implemented within existing MoCs and become part of routine care of people with pain. This is highlighted by recent examples of Internet-delivered mental health interventions that despite being based on evidence-based principles and found to be efficacious in controlled clinical trials, have failed to show any benefit when implemented into routine care [61].

E-registries for persistent pain care

Stanford University has developed and implemented the Collaborative Health Outcomes Information Registry (CHOIR) system (https://choir.stanford.edu/implementation/) in response to the Institute of Medicine's Report Relieving Pain in America [62]. This open source, open standard, free data collection software was developed in partnership with cross-discipline scientists, clinical experts and the National Institutes of Health, which allows clinicians to obtain qualitative information from people with pain in a safe, secure and easy-to-use system. The obtained information is designed to inform the optimal treatment for each individual, for example, by providing summary charts about how a person responds to treatment over time. CHOIR has been integrated into the clinic using Internet-enabled mobile devices (e.g. iPads). At present, there are approximately 15,000 unique patients, 64,000 visits and 40,000 follow-up visits. In addition, at Stanford Medical Centre, CHOIR is used in clinical practice and research.

In Australia, the electronic Persistent Pain Outcomes Collaboration (ePPOC: http://ahsri.uow.edu.au/eppoc/index.html) is a recent strategic implementation initiative of the Australian and New Zealand College of Anaesthetists, Faculty of Pain Medicine, which aligns with the National Pain Strategy [14]. The first phase started in 2013, with further cross-sector development by the Faculty of Pain Medicine, the Australian Pain Society and the wider pain community. The implementation strategy uses a systemised approach for the electronic collection of a standard set of data items and assessment tools by specialist pain services throughout Australia and New Zealand to measure person-centred and system outcomes in response to treatment [63]. De-identified data are analysed by ePPOC, with results provided to participating services every 6 months. Currently, data of over 6000 patients have been collected, describing demographic and clinical characteristics (e.g. the back was the most common painful site (43%)), along with information about care received. These data will inform a national benchmarking system for the pain sector, with a view to levering improved outcomes and best-practice interventions that are key components of MoCs. Data will also enable development of a coordinated approach to pain research in Australasia.

Telehealth for pain care

Telehealth to deliver pain care has been implemented using a variety of models, including store-and-forward, direct contact consultation, hub and spoke consultation and home-based models of service delivery [64]. TelePain is an initiative developed and implemented in Washington State, Wyoming, Alaska, Montana and Idaho (USA), and uses video-, Internet- and telephone-conferencing technologies to bridge the gap in community needs for pain services [65]. Using a cluster RCT of a telehealth-enhanced intervention, the comparative effectiveness (cost and health outcomes) of Tele-Pain compared with usual care is currently being explored [65]. Eaton and colleagues outline specific challenges in the implementation of TelePain (systems, clinician and patient, time and cost), highlighting the critical role of strong cross-sector engagement as a cornerstone of successful implementation, with these findings being consistent with recent recommendations [38]. Similarly, a range of telephone- and Internet-delivered care models for people with OA pain are currently being explored through the Australian Centre for Health Exercise and Sports Medicine (http://healthsciences.unimelb.edu.au/research2/physiotherapy-research/chesm).

The 'how to do it' of eHealth implementation, however, appears to have leapfrogged the 'what to do' regarding best evidence. The interpretation of evidence from current studies is complicated by clinical heterogeneity, different modes of telehealth (telephone versus visual communication) and variable outcomes (systems versus person-centred). A recent review of telehealth [64] highlighted the need for more high-quality studies, which measure person-centred health outcomes and risk profiles, and which develop pain services to better align with patient needs. A related meta-analysis revealed an overall benefit of telehealth interventions over control conditions and equivalence with in-person interventions; however, some reviewed studies showed no benefit compared with control interventions [66]. However, some of the reviewed studies found no benefit for telehealth over control conditions. Some methodological concerns among the examined research included poor research quality, small sample sizes, and the examination of telehealth pain interventions without proven efficacy for in-person treatment.

EHealth tools for clinicians to deliver pain care

Clinical decision aids for pain care

Stratified care approaches aim to improve the allocation of resources to patients by using a more systematic approach to management decisions. STarT Back (http://www.keele.ac.uk/sbst/) is an example of a stratified care approach that matches people with back pain to treatments based on prognosis or risk of poor clinical outcome [67]. The STarT Back approach uses a simple tool to match patients to appropriate treatment packages. Using this approach, the IMplementation to improve Patient Care through Targeted treatment (IMPaCT) study has shown that STarT Back can be successfully embedded into primary care, and the approach has been extended across the United Kingdom and worldwide [68] (see Chapter 2 for further detail). The use of a computer template (pop-up) was a key component of implementation for this trial in community settings, prompting physicians to complete the stratification tool during the consultation and subsequently receive a risk group-matched treatment recommendation. Stratified care for back pain implemented in family practice led to significant improvements in patient disability outcomes and halving of time off work, without increasing healthcare costs [68].

Other point-of-care e-tools for pain care

The Extension for Community Health Outcomes (ECHO Project) is an example of successful implementation of a telehealth program that provides pain education, pain management and consultation to healthcare providers in rural and underserved communities in New Mexico [69]. Using telementoring, the ECHO model includes: (1) adherence to best practices to reduce variation in care; (2) case-based learning and (3) data tracking to monitor outcomes. Live weekly clinics are facilitated by ECHO pain specialists. From January 2010 to December 2012, pain clinics were conducted with 3835 total cases of participation, involving 763 unique health professionals from 191 different sites [69]. Although the ECHO program showed significant improvements in providers' self-reported knowledge, skills and practice, person-centred outcomes are unclear.

Social media platforms for disseminating/sourcing best-practice knowledge in pain care

Body in Mind (http://www.bodyinmind.org/) is a collaborative initiative developed with a vision to promote better understanding of clinical pain sciences. This translational e-resource has provided over 600 blog posts (from over 200 authors in 22 countries), mainly focussing on translating recent evidence-based pain research into more clinically usable forms. On a monthly basis, the site registers over 25,000 visitors (20,000 unique) from over 140 countries with a reach of around 2000 subscribers. An observational study was conducted to examine the uptake of clinical research disseminated via social media. Over 3 months, findings from 16 studies were posted and survey outcomes indicated that social media significantly increased views and downloads. This, in turn, was statistically linked to the viral spread of the information (i.e. likes, shares and re-tweets) [70].

EHealth tools to support patients' participation in pain care

Online resources for pain care

In Australia, the development of websites such as pain*HEALTH* (http://painhealth.csse.uwa.edu.au/) and Pain Management Network (http://www.aci.health.nsw.gov.au/chronic-pain) has been informed by MSK MoCs, developed by Health Networks in Western Australia [59] and New South Wales, respectively [71]. Both websites have been designed to enable patients to develop skills and knowledge in pain co-care in partnership with patients and healthcare providers. For pain*HEALTH*, three iterative development phases engaged a cross-disciplinary team of clinicians, researchers, patients, policy-makers and technology developers and were underpinned by research evidence. Cross-sector partnerships helped drive effective implementation of these websites. For example, pain*HEALTH* has implementation partners including the Australian Pain Society and the Australian Physiotherapy Association. Implementation has also been assisted through wider dissemination through links to patient advocacy groups (e.g. Arthritis Australia and painAustralia), and pain*HEALTH* content has also been co-embedded within other resources developed by the Australian Government for veterans (https://www.veteransmates.net.au/topic-38) and distributed to approximately 30,000 doctors in Australia and New Zealand. Google Analytics™ data (23 May 2016) show the effective reach of pain*HEALTH*: 6,016,196 total hits from 465,850 unique visitors, located in over 140 countries, showing that implementation can reach across jurisdictions.

Online pain care interventions

Internet-delivered interventions are different from the well-known ‘telehealth’ interventions, as they involve more than the delivery of a face-to-face intervention through videoconferencing. Internet-delivered interventions can be differentiated from mobile applications [72] and from informational webpages [73], in that they provide a *system for learning* information and skills. Various models for these interventions exist, including interventions provided with regular clinician support throughout, for example, through secure e-mail or telephone, and interventions with very limited to no clinician support. Some interventions have open access and are available at all times [74], others require some form of referral or registration and are available only intermittently [75,76].

Online interventions can be used to support patients learning about pain, and practical self-management skills for improving functional ability, minimizing disability and maintaining good mental health and quality of life; all critical components of evidence-informed, contemporary MoCs [14,59,62]. These interventions often employ the same principles, provide the same information and teach the same self-management skills as face-to-face interventions. However, they are carefully designed to be provided through the Internet and computer without the need for face-to-face contact, thereby bypassing geographic or socio-demographic care disparities often associated with conventional face-to-face models of intervention [77].

There are numerous ways in which Internet interventions are being considered and formulated to support the implementation of best-practice MoCs. Different intervention models are being considered and developed for different populations and with different clinical foci. For example, a physiotherapist-led intervention is currently being trialled, in which patients with knee OA access PainCOACH (http://sph.unc.edu/global-health/ggg-paincoach-project/), an Internet-delivered pain coping skills intervention, in parallel with several 30-min physiotherapy sessions delivered through a video telephony service [78]. This is one of very few interventions to involve remote delivery of structured physiotherapeutic intervention alongside an Internet-delivered intervention [79], although some interventions focussed on promoting physical activity are emerging [80].

While there is encouraging preliminary evidence [81,82], clinical improvements (e.g. in pain, disability, anxiety and depression levels) have not been consistently observed and the magnitude of clinical improvements varies significantly across studies. Some interventions have high levels of patient drop-out (>50% in some cases), whereas others have observed high levels of acceptability, engagement and retention [83]. In contrast, systematic review and RCT evidence for the use of Internet-delivered pain management have shown that programs can be cost-effective [84] and deliver positive patient-reported health outcomes (i.e. pain, quality of life, psychological and physical functioning) [81,85,86]. With rare exceptions, few interventions have been evaluated with large cohorts or across multiple trials [81,82]. While most developers are still engaged in basic 'proof-of-concept' evaluation studies to determine whether, when, where and with whom Internet interventions may be effective, there are examples in which the emerging evidence is moving beyond the basic 'proof of concept'.

The Pain Course is an Internet-delivered intervention, which is currently offered by the eCentreClinic (www.ecentreclinic.org) and has been undergoing iterative development and evaluation. The Pain Course was designed on the principles of transdiagnostic intervention, that is, to be suitable for people with a broad range of different persistent pain conditions. Components of the course are summarized in Table 1.

The Pain Course closely models traditional face-to-face pain management programs and aims to:

- Provide information that helps patients to make sense of pain
- Teach evidence-based cognitive and behavioural skills (thought challenging, de-arousal strategies, activity scheduling, activity pacing, graded exposure)
- Reduce pain-related disability, anxiety and depression by supporting the adoption of evidence-based skills taught within the program.

The Pain Course has been evaluated in several randomised controlled trials and single-group open trials involving more than 800 Australians with persistent pain (including OA, RA, spinal cord injuries, headache and migraines) [75,83]. Accumulating evidence shows associated significant clinical reductions in pain, disability, anxiety and depression levels and increased patient self-efficacy. The Pain Course has been proven highly acceptable to patients and is very time-efficient [75]. Using an entirely self-guided version of the Pain Course, positive outcomes are also evident, including high levels of engagement and significant improvements in levels of pain, disability, anxiety and depression. Trials of the Pain Course are ongoing, including longer-term follow-up projects, implementation studies and economic evaluations. Efforts are underway to examine predictors of response to the Pain Course to understand patient-related factors that may affect clinical outcomes [87], a consideration essential to realize the potential of Internet-delivered interventions and will inform their eventual adoption as a component of routine pain care.

Outside of controlled clinical trial evaluations, there are no published large-scale reports for the implementation of Internet-delivered interventions into routine care for MSK or other pain conditions [81,82]. Very little is known about the real-world potential of these programs within, or as a complement to, routine health care. However, pragmatic approaches such as that used to implement pain*HEALTH* are important: gaining easy access to reliable knowledge and skills that can assist in

Table 1
Timetable and content of The Pain Course.

Lesson	Time before next lesson	Lesson content	Primary skill taught	Additional resources
1	1 week	Education about the prevalence of chronic pain and symptoms of anxiety and depression. Information about pain perception and the nervous system. Introduction of a CBT model and explanation of the functional relationship between physical, thought and behavioural symptoms. Instructions for identifying their own symptoms and how their symptoms interact.	- Symptom identification - Symptom formulation	- Sleep management - What to do in a mental health emergency - Working with health professionals and treatments for chronic pain
2	2 weeks	Introduction to the basic principles of cognitive therapy and importance of managing thoughts to help manage pain but also anxiety and depression. Instructions for monitoring and challenging thoughts.	- Thought monitoring - Thought challenging	- Structured problem solving and worry time - Challenging beliefs
3	1 week	Introduction to the physical symptoms of anxiety (i.e. hyper-arousal) and depression (i.e. hypo-arousal) and their relationship to emotional well-being and managing the impact of chronic pain. Instructions about controlling physical symptoms using de-arousal strategies such as controlled breathing and scheduling pleasant activities.	- Controlled relaxation - Pleasant activity scheduling	- Attention management and chronic pain - Chronic pain and panic attacks - A list of 100 pleasant things to do
4	2 weeks	Introduction to the behavioural symptoms of anxiety, low mood and chronic pain. Explanation of the overdoing–underdoing cycle of physical activity and issues around the fear and the avoidance of physical activities. Instructions for pacing and gradually and safely increasing physical activities.	- Activity pacing - Graded exposure	- Assertive communication
5	2 weeks	Information about the occurrence of lapses in pain, depression and anxiety. Information about the signs of relapse and the importance of goal-setting into the future. Instructions for creating a relapse prevention plan and goal-setting	- Relapse prevention - Goal setting	–

building capacity in the self-management and co-care of MSK pain, where safe and appropriate, should not be withheld.

Social media for pain care

Management of long-term conditions such as pain offer great potential for digital health management through increased participation, flexibility, autonomy and mobile self-management [6]. This is evident with the shift towards interactive and engaging self-management applications such as Pain Tool Kit (http://www.paintoolkit.org/). The Tool Kit was found 'by a patient for patients', with the idea to create a resource to encourage self-management and active engagement. Applications such as the Pain Tool Kit provide patients with useful self-management resources, links and ability to track pain and activity in one convenient location. Building on the utility of digital applications, that is, social media tools (e.g. social networks and blogging platforms) is another key driver of engaged and empowered patients playing a significant role in their own health care [88,89]. However, evidence for their effective use in MoCs for pain-related conditions is immature. The few systematic reviews examining social media use in chronic health conditions include only a small sample of pain-related conditions [84,88,90]. Furthermore, available best evidence for social media use for pain conditions cited here, is represented by a demographic of predominantly well-educated Caucasian females of middle-income status aged 40–60 years. This profile conflicts with the real-world diversity of populations affected by persistent MSK pain, especially minorities and people in developing nations [91]. Further evaluative work that better represents real-world clinical casemix is therefore needed.

Online communities: social networks for pain care

Platforms such as Facebook have given rise to a growing number of online patient peer-to-peer support communities, where people connect to source and share information, and offer each other support (see 'Surviving Chronic Pain' https://www.facebook.com/SurvivingChronicPain/). As an example, launched in 2012 by people living with chronic pain as a peer support community, 'Surviving Chronic Pain' currently has over 54,000 members. Evidence for use of online support communities as an implementation strategy suggests that engagement in such environments fosters positivity, emotional expression and support [92, 93].

Furthermore, some RCT-level evidence shows that social networking can improve health outcomes [94, 95]. The online Chronic Pain Management Program (CPMP) [94] evaluated a comprehensive online program for self-management of MSK pain incorporating social networking (personal profiles and discussion forums) compared with routine care. The program was co-developed with support from the National Institute of Neurological Disorders and Stroke, in conjunction with the University of Arizona, USA. The culmination has been the online platform – 'Goalistics' CPMP (https://pain.goalistics.com/). Development was an iterative holistic and encompassing process, involving psychologists specialised in treating persistent pain and a group of people living with persistent pain. CPMP has achieved significant improvements in pain outcomes (pain severity, pain-related knowledge, pain interference and pain-induced fear) compared with the usual treatment. This well-designed online intervention involved clinicians and patients in the design, with regular formative evaluation along the way to ensure the program's applicability to real-world conditions (e.g. self-directed and self-paced) and adhered to health informatics methodologies.

Similar findings were obtained in a further RCT comparing online self-management with usual treatment [95]. The portal included a discussion forum/centre for people with arthritis or fibromyalgia to connect, support and share information. The portal was built to replicate an offline management program, which has run successfully through Stanford University for over 30 years and is still in place today [95]. The online portal was developed to deliver the same successful offline model to a higher range of individuals (http://patienteducation.stanford.edu/programs/asmp.html). Participants indicated positivity towards the social networking feature of the Arthritis Self-Management Program and strong engagement and significant improvements were seen for pain, health distress, activity limitation, self-reported global health and self-efficacy [95].

Blogging platforms for pain care

Beyond social networks, blogging provides a platform for emotional self-expression and support for people living with pain [96], although applications are geared primarily towards psychological self-management [96–98]. High-level evidence is lacking, with most outcomes focussing on the effects of maintaining one's own blog [96, 97, 99]. A survey of individuals who blogged to communicate their pain experiences suggested positive effects (improved inter-personal connections, less isolation, more accountability, insight, understanding and emotional catharsis) [96]. The social dimensions of blogging also appear important amongst people living with arthritis and fibromyalgia, with outcomes indicating that individuals who reported a lack of social support derived most benefit [97]. Social and psychological health benefits can also be derived from engaging with others' blogs [98].

Practice Points

- Pragmatic approaches to implementation (not just RCTs) using eHealth are necessary to lever stakeholder engagement and resonate with real-world needs. For example, Internet-based resources such as pain*HEALTH* can help build capacity and increase access to best-practice pain self-management and co-care for MSK health.
- Emerging evidence supports the potential of Internet delivery of pain management programs across a range of MSK health conditions as a way of building capacity and increasing access to best-practice MSK health.
- There are some preliminary data to support meaningful differences in the clinical outcomes of available Internet-delivered interventions targeting MSK pain
- Most Internet-delivered interventions for MSK pain conditions are currently available primarily through participation in clinical trial evaluations. Few or none are available as a part of routine health care. Accordingly, evidence for effectiveness is related primarily to clinical trial contexts and further research is needed to evaluate implementation effectiveness in routine care and real-world' self-management.

Role of eHealth in supporting implementation of MSK MoCs across differently resourced settings

What and how

While not specific for MSK health alone, two key practical resources are relevant to the consideration of 'what' (availability/evidence) and 'how' of implementation of eHealth across differently resourced settings. First, the Atlas of eHealth country profiles, which is based on findings of the third global survey on eHealth 2015, with data collected from 125 WHO Member States [5]. Survey questions covered diverse areas of eHealth from electronic information systems to social media, policy issues and legal frameworks. The country profiles are grouped by themes (eHealth foundations, legal frameworks, telehealth, electronic health records, eLearning in health sciences, mHealth, social media and big data) to provide an overview of the eHealth landscape in individual countries. Secondary indicators (e.g. health workforce density and location; ICT Development Index rank as a measure of the information society; mobile-cellular subscriptions (% inhabitants) and Internet users (% individuals)) provide the country context for eHealth data. The country survey tools may be downloaded from http://www.who.int/goe. Country profiles can be accessed at http://www.who.int/goe/publications/en/. This Atlas could be used to make decisions about which eHealth solution might be most helpful for MSK health, which settings and how it could be implemented based on the eHealth landscape.

Second, WHO provides a snapshot of eHealth technologies developed and evaluated specifically for implementation into less resourced settings and which have the potential to improve health outcomes, or to offer eHealth solutions to unmet healthcare needs [100]. Context here is important, as according to the World Economic Forum Report 2015, ' … some 90% of population in low-income countries and over 60% globally have never gone online', highlighting that there is still a long way to go [101]. A broad range of eHealth technology applications for non-communicable diseases are covered (e.g. case-based smartphone messaging platforms, ePharmacyNet system, Health and hospital information system, health workforce information systems, medical cloud, mobile technology to connect patients to remote doctors, new media to train health workers, primary healthcare continuous quality improvement tools, remote healthcare solutions, telemedicine networks, teletrauma and treatment response software) [100]. One example that could be applied to MSK health care is a Telemedicine network developed in Switzerland to scale up health professional education through eLearning/mLearning using a suite of software tools specifically designed to work in low-bandwidth, low-infrastructure settings, to provide distance education and tele-expertise consultations. For remote education, slide presentations are converted using open-source office automation software (OpenOffice) into a webcastable format including an instant messaging tool to enable interactivity. This eHealth solution is suitable for rural, primary, secondary and tertiary care settings and has been implemented in Mali, Mauritania, Senegal, Burkina Faso, Niger, Ivory Coast, Chad, Cameroon, Congo, DRC, Guinea, Madagascar, Liberia, Ghana, Tanzania, Egypt, Tunisia, Morocco, Bolivia and Laos [100].

Partnership models

Partnership models that link academic and governmental institutions and the private sector can also help in the development, implementation and evaluation of eHealth solutions for MoCs in low-resource settings. A recent analysis undertaken in 16 low- and middle-income countries focussed on the use of eHealth strategies that engaged the private sector to address key health system challenges. Findings showed that eHealth programs are being implemented for different reasons, including 42% to extend geographic access to health care, 38% to improve data management and 31% to facilitate communication between patients and health professionals [102]. Key issues highlighted for successful implementation included more sustainable funding sources, higher cross-sector support for the adoption of new technologies and improved evaluation of impact [102], issues also highlighted by our recent work [38].

The Réseau en Afrique Francophone pour la Télémédecine (RAFT) initiative is another interesting example of a systematized approach to the development, implementation and evaluation of eHealth solutions for educational, clinical (health systems and clinician tools) and public health activities [103]. The RAFT (8) is a telemedicine network created by University hospitals and the University of Geneva in French-speaking Africa (Mali) in 2001. In a recent perspectives paper, RAFT collaborators highlight the lessons learnt over the decade of using eHealth solutions [103]. For effective implementation of eHealth and telemedicine in low- and middle-income economies, key considerations included context (resources, infrastructure and funding), the needs of key stakeholders and the outcomes derived from theoretical and practical experience.

Implementation frameworks

Frameworks from implementation science can be used for adapting effective eHealth interventions to the local context. For example, the Consolidated Framework for Implementation Research (CFIR) provides a comprehensive overview of domains and constructs to consider for evaluating and addressing implementation challenges [104]. CFIR enables researchers and decision makers to systematically adapt an existing health services intervention, including eHealth interventions, to fit the local context. Similarly, several behaviour change science frameworks such as the Theoretical Domains Framework are available to guide intervention selections to address behaviour change [105]. As methods in implementation science continue to evolve, having team members with expertise in this field would be essential to a successful implementation process. Recently, we have also developed a globally informed framework for judging 'readiness' and 'success' to support the evaluation and implementation of MSK MoCs. This framework provides an important internationally applicable benchmark for the development, implementation and evaluation of MSK MoCs [38].

Summary

Accumulating evidence supports the inclusion of eHealth as an important component for the effective implementation of MSK MoCs. EHealth can enable implementation at the health systems (macro) level, health service delivery (meso) level and clinical and patient (micro) level. EHealth can help bridge the care gap experienced by remote and underserved populations, to improve timely and sustainable access to best-practice MSK care for patients, facilitate upskilling of health professionals and improve health system efficiencies. Effective implementation faces many challenges, including the necessity to embed services in the institutional framework of countries and requiring countries to have an eHealth strategy and related policies and coordination structures. These challenges can also be seen as opportunities for partnership and to build flexible eHealth ecosystems that can be implemented across different care settings. Much more high-quality research, moving beyond the studies of effectiveness evaluation, is needed to explore, which eHealth solutions, technologies and tools will work most effectively in different real-world settings and 'how' eHealth can be most effectively used to lever implementation of MoCs for MSK health.

Research priorities

- Implementation research is needed to increase our understanding of eHealth interventions for what' works (health outcomes and cost-effectiveness, acceptability and safety, sustainability), as well as for whom, when and in what formats (e.g. mHealth, online and social media platforms) these interventions are most effective in MSK health.
- Implementation research is needed to increase our understanding of how best to use eHealth across different care settings as both a lever for effective implementation, and as a component of care, in MSK MoCs.
- Implementation research is required to understand what features of computerised clinical decision support systems are associated with successful and sustainable implementation and positive patient-reported health outcomes for MSK health. In particular, integrating clinician-focussed tools with patient tools to facilitate shared decision-making and co-care is a priority.

Conflicts of interest/declarations

All authors declare no conflict of interest. Helen Slater and Andrew M Briggs were not involved in editorial processes or decisions regarding this manuscript.

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